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MANUAL
OF
FIELD ENGINEERING
VOL. I
(ALL ARMS)
1933

LONDON
PUBLISHED BY HIS MAJESTY'S STATIONERY OFFICE
To be purchased directly from H.M. STATIONERY OFFICE at the following addresses
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By Command of the Army Council,

THE WAR OFFICE,
30th June, 1933.

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GLOSSARY OF TERMS

Abatis.—An obstacle formed of trees or branches of trees picketed to the ground, with their points towards the enemy.

Batter.—The slope of the face of any earthen, stone or masonry structure which is not vertical.

Bay.—The distance bridged by one set of baulks or road-bearers.

Berm.—The distance between the edge of an excavation and the mound formed of the excavated earth in a defence work.

Bight.—The portion of a rope used double when the ends are not available.

Borrow-pit.—An excavation from which earth is taken for a particular purpose, *e.g.* building a breastwork.

Breastwork.—A defence work of which the greater portion of its height is above ground level.

Butt.—The thick end of a spar.

Command.—The vertical height of the crest of a work above the ground level or above the crest of a neighbouring work.

Communications.—Roads, railways, waterways and air routes.

Cover.—Concealment from view or protection from enemy projectiles.

Crest.—The highest point of a parapet, usually the intersection of the superior with the interior slope.

Dead ground.—Ground over which observed or unobserved fire cannot be brought to bear.

Defilade.—The adjustment of the levels of the crest and interior of a work to secure cover for the defenders.

Dog.—A bar of iron of which the ends are pointed and bent inwards at right-angles—used for fastening heavy timbers together.

Dug-out.—An underground chamber or passage.

Gap.—With reference to bridging, that portion of a river, canal, sunken road, ditch or other obstacle, over which a bridge is made.

Gradient.—A slope represented by a fraction, *e.g.* 1/30 represents a rise or fall of one unit measured vertically for very 30 units measured horizontally.

Groundsill.—The bottom member of a frame or sett used in work underground.

Headcover.—Protection against frontal or oblique fire for the heads of men when firing over a parapet.

Helve.—Handle of pickaxe or felling-axe.

Overhead cover.—Protection by means of a roof, against splinters, shells or bombs.

Parados.—A bank of earth constructed to give protection against reverse fire, and the back burst of high-explosive shells.

Parapet.—A bank of earth constructed to give protection against frontal fire, and the forward burst of high explosive shells.

Profile.—The outline of the section of a work at right-angles to the crest line.

Relief.—A party of men who are on duty or who work for a given length of time. This word is used colloquially to express the length of time for which the party works.

Retrenchment.—A system of trenches sited to form a second, though not necessarily a separate, line of defence, usually to reduce the number of rifles required in the forward system.

Sap.—A trench dug by men working at the bottom and constantly extending the end towards the enemy.

Slope.—
Interior.—The inner slope of a parapet extending from the crest to the fire step.
Exterior.—The outer slope of the parapet from the exterior crest to the ground level.
Superior.—The slope of top of the parapet immediately in front of the crest.

Spike.—A large nail of heavy section from 5 in. to 10 in. long.

Spitlock.—To mark out a line on the ground with the point of a pick-axe.

Spoil.—The material resulting from any excavations.

Tasks.—The amount of work to be completed by a man, or party of men, during one relief.

Task work.—A certain amount of work to be completed, irrespective of the time it may take.

Time work.—Work to be continued for a certain period of time, irrespective of the amount done.

Template.—A pattern, guide or model used to indicate the shape any piece of work is to assume when finished, *e.g.* wood laths nailed together to outline the section of a trench or parapet used to check the accuracy of the work.

Topsill.—The top member of a frame, sett or case used in work underground.

Traverse.—A buttress of earth provided between two adjacent portions of a fire or communication trench for protection against enfilade or oblique fire, and to localize the effect of shell bursts.

Trenails.—Pegs of hard wood used for jointing heavy timbers instead of dogs or spikes.

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CHAPTER I

INTRODUCTION

1. *Object of manual*

1. This manual is for the use of all arms. It describes only that engineering work for the execution of which in war, units of all arms will themselves be responsible, and it indicates how units should be trained for this responsibility in peace.

2. In war a large amount of skilled and unskilled labour must be employed in engineering work both in and in rear of the forward area, if combatant troops are to develop their fighting capacity to the full.

Skilled labour is provided by the engineers, and is used either with or without the assistance of working parties of other arms or civilian labour.

The working parties must, if in the proximity of the enemy, be provided by the combatant troops.

2. *Classification of field engineering*

1. Field engineering may be divided into two categories :—

i. Work for which all units and formations are responsible.

ii. Work for which engineers only are responsible.

2. Work for which all units and formations are responsible includes :—

i. Siting, organization and construction of their own protective works, including obstacles, clearing field of fire, light shelters and battery positions.

ii. Concealment.

iii. Assault bridging and simple work connected with fords.
iv. Improvements to tracks and communications.
v. Simple anti-tank obstacles.

3. Engineers should be employed on work which is technical, and for which they alone have the necessary training and equipment. They should not be employed on work which lies within the capacity of other arms, unless, in the opinion of the commander, such a course is necessary owing to the urgency of the operations.

A close liaison between engineers and other arms is essential at all times both in peace and war.

In particular, although engineers carry out reconnaissances themselves, they will depend largely on information received from forward troops of other arms, *e.g.* width and depth of streams, nature of obstacles, to enable them to provide quickly men and material.

In work for which other arms are responsible, engineer assistance will be restricted to the provision of technical advice or minor assistance in technical details.

CHAPTER II

TRAINING

3. *Training of instructors*

1. i. *Unit course for instructors.*—Before the rank and file commence their training, it is necessary that officers and N.C.Os. should learn the principles and important details of field engineering.

For this purpose a course of instruction should be organized within the unit during the individual training season. This course should be attended by officers and senior N.C.Os., the following subjects being studied:—

(*a*) The correct application of various types of field works.
(*b*) The proper standards of performance.
(*c*) The necessity for carefully planned organization before putting work in hand.

ii. *Syllabus.*—Preparation of the syllabus for this course of instruction is left to unit commanders. The following sub-paragraphs only contain suggestions for inclusion in the syllabus:—

(*a*) How this manual is arranged and the object of field engineering.
(*b*) The use and distribution of materials and tools; how tools are carried in units and the importance of digging drill (Chapter III).
(*c*) How field works assist in defence (Chapter V).
(*d*) Obstacles (Chapter VII).
(*e*) Details of protective works and their application to the ground (Chapters IX, X, XII and XIII).
(*f*) Organization of work (Chapter IV).
(*g*) Calculations of labour, tools and materials for various works (Appendix I).
(*h*) Instruction in the remaining chapters should be carried out later when time is available.

4. *Training of rank and file*

1. The training of the rank and file should be undertaken as set forth in the following paragraphs.

2. **Individual training (Infantry).—**
Instruction may include:—

(*a*) *Names of tools and their use.*—(Chapter III.)

(*b*) *Digging drill.*—(Chapter III.)
(*c*) *Construction of simple weapon pits.*—(Chapter IX.)
(*d*) *Importance of clearing field of view.*—(Sec. **18.**)
(*e*) *Concealment.*—(Chapter VI.)
(*f*) *Obstacles.*—(Chapter VII.)
(*g*) *Filling and laying sandbags.*—(Secs. **6** and **46.**)

3. **Squadron, battery and company training.**—During this period the soldier should be taught the principles of field engineering and the various types of works.

Instruction should include the following :—

(*a*) The improvement of a weapon pit, digging a section post, and later a platoon post and company locality.
(*b*) Machine gunners should make a hasty machine-gun emplacement and slits for shelter of their detachments, and should later mark out and dig a post for a machine-gun section).
(*c*) The repair and maintenance of a fire trench. Importance of drainage.
(*d*) The siting and erection of a simple artificial obstacle.
(*e*) Assault bridging.
(*f*) Revetment of trenches.
(*g*) Loopholing a wall.
(*h*) Blocking of roads.
(*i*) How to erect a simple shelter (splinter proof).

Later, when time and opportunity permit :—

(*j*) Putting a group of buildings into a state of defence.
(*k*) The construction of a defended locality which should then be occupied by troops from 12 to 24 hours; during this time new work can be constructed and practice given in maintenance.

4. **Battalion, regimental and brigade, R.A. training.**—Tactical schemes should include the actual application and construction of the various types of field engineering works and the rapid and deliberate organization of work in a battalion or brigade sector.

In this period instruction should be given in the issue of tools down to the individual man within the unit, supplemented, if necessary, by the brigade and divisional reserves.

In tactical exercises without troops, both indoor and out, problems connected with field works should, whenever possible, be introduced, so that the necessity of the subject is kept in mind.

5. **Notes on training of arms other than infantry.**—

i. *Artillery.*—A suggested programme of work for artillery is :—

INDIVIDUAL TRAINING PERIOD

(*a*) Names of tools carried in artillery units. Their uses and maintenance (Appendix II).
(*b*) Digging drill and its importance (Chapter III).
(*c*) Construction near barracks of :—
Slits for gun detachments.
A command post.
An observation post.
Concealment of guns and O.Ps. (Chapter XII).

COLLECTIVE TRAINING PERIOD

(*d*) Concealment and provision of cover for artillery brigade headquarters and telephone exchange (Chapter XII).
(*e*) The provision of cover and concealment for gun detachments, observation and command posts, both by day and night.
Protection at gun positions for dumps of ammunition.
(*f*) Siting and construction of cook-houses and latrines at wagon lines or gun positions.

ii. *Cavalry.*—A suggested programme of work for cavalry is :—

INDIVIDUAL TRAINING PERIOD

(*a*) Names of tools.
(*b*) Digging drill.
(*c*) Construction of weapon pit.
(*d*) Wiring.

COLLECTIVE TRAINING PERIOD

(*e*) Reconnaissance for tracks. Making tracks including gaps in hedges (Chapter XV).
(*f*) Passage of rivers (Chapter XVI).
(*g*) Simple repairs or improvements to roads (Chapter XV).

iii. *Royal Tank Corps.*—Training should include :—

INDIVIDUAL TRAINING PERIOD

(*a*) Digging drill.

COLLECTIVE TRAINING PERIOD

(*b*) Blocking roads against armoured cars and light tanks (Sec. **22**).
(*c*) Passage of rivers (Chapter XVI).

6. **Importance of tactical setting.**—It is most important that all work should be carried out in a tactical setting. In tactical exercises without troops problems connected with field works should, whenever possible, be introduced.

7. **Night work.**—The importance of night work cannot be overstated. On active service most protective works are executed during the hours of darkness, and unless soldiers are thoroughly familiar with the use by night of their tools and materials, serious delay is bound to occur.

8. **Training while wearing anti-gas respirators.**—The wearing of respirators, especially at night, by men who are unused to them, very greatly reduces the amount of work which can be done. It is essential, therefore, that all ranks be frequently practised in carrying out field engineering work while wearing respirators.

CHAPTER III

ELEMENTS OF FIELD ENGINEERING

5. *Tools*

1. To obtain the best value out of tools they must be kept sharp and clean.

2. Tools used in the field may be grouped under three heads :—

i. Entrenching tools.
ii. Cutting tools.
iii. Miscellaneous tools.

3. **Entrenching tools** are the pickaxe, the shovel, the spade and the crowbar.

The pickaxe is intended for loosening soil, the pointed end is for use in hard ground and the chisel end for soft ground. Weight 8 lb.

The shovel is issued for clearing away the soil loosened by the pick. Weight (G.S. pattern) 3½ lb., helve ~~28~~ 27 in.

The spade is used chiefly for cutting sods and trimming slopes. It is also used for digging in stiff soil, such as clay, and in narrow ditches. Weight 5¾ lb.

The crowbar has many uses. Besides being employed as a lever in lifting weights, it is used for breaking up lumps of masonry, brickwork, etc., moving large stones and for making holes in walls.

4. **Cutting tools.**—The service cutting tools are :—

i. The *felling-axe*, *cross-cut saw* and *folding saw*—are used for felling trees and cutting timber.
ii. The *hand axe*, *bill-hook* and *hand saw* are used for clearing brushwood, hedges, and for trimming. The *reaping hook* is used for cutting corn, etc., to clear field of fire.

The *felling-axe* can be used with effect only by a man trained to use it.

The *cross-cut saw* is safe and easy to use in the hands of unskilled men, and is worked by two men who pull the saw in turn across the timber. No pushing is required. When used for felling trees, wedges are required to prevent the saw from jamming.

When cutting tools are in use, means to keep them sharp must be provided, *e.g.* grindstone, saw sets, files and honing stones.

5. Miscellaneous tools.—

i. *Mauls and sledge-hammers.*—These are wooden and iron hammers, weighing about 14 lb. They are used for driving wooden or iron pickets into the ground.

To use them the picket should be held at the proper angle and given one or two taps to make it enter the ground. The handle should then be held with both hands near the end and the hammer head swung in a circle, bringing it down on the head of the picket. As the maul or hammer strikes the picket it should be moving along the line of the picket, and the handle should be at right-angles with the picket. The flat face of the maul or hammer will then strike the flat head of the picket, the picket will thus be driven in at the right angle and will not split.

ii. *Spanners and wrenches.*—These are used for screwing nuts on to bolts. The nut must be screwed with care on the bolt, and not be forced. Nuts which have become rusty may be loosened by soaking them in kerosene or by heating them.

iii. *Augers* are used for making holes in timber. Great care must be taken that the small point at the end of the auger is not broken. The auger should be screwed in, whenever possible, at right-angles to the face of the timber.

6. *Materials*

1. **Earth** can be used in many ways for giving protection in field defence. For filling sandbags, earth is used in preference to other materials.

Earth slopes, when freshly cut, will stand nearly vertical for a short time, but quickly disintegrate and crumble after exposure to air, sun, rain and frost, and in time will stand only at the slope of excavated earth, which varies from 1/1 to 2/3. Therefore, to make earth stand at a steeper slope, it must be revetted (*see* Sec. **46**).

The weight of earth varies from 80 lb. to 100 lb. per cu. ft.

2. **Sand, shingle, chalk and clay** have to be used in field works. The following points should be borne in mind :—

Sand cannot stand without revetment.

Shingle possesses good stopping power against bullets, but splinters easily; between stout planks it is very useful and effective. (*See* Table of Penetrations, Sec. **35**.)

Chalk is very conspicuous. Clay is not good for filling sandbags as voids must occur; therefore, penetration of a bullet is greater than in earth.

3. **Stones.**—Stones in a parapet stop bullets but cause damage from splinters.

4. **Sods** are pieces of turf used for revetting. They are laid like bricks, and are cut approximately to 18 in. × 9 in. × 4½ in. thick. They are laid grass downwards.

5. **Timber.**—The most common forms of timber which are used by all arms include :—

i. Scantlings, 3 in. × 4 in., used in construction of shelters.
ii. Round pickets, 3-in. to 5-in. diameter, used in revetment work and for wiring.

6. **Brushwood.**—Consists of thin straight branches of bushes. It is used for making hurdles for revetting purposes and for hutting, and for road-making, in which case it is tied up in bundles. It is bulky to transport.

When it is cut the leaves and twigs should be removed.

7. **Sandbags.**—The service pattern sandbag is of jute and measures 33 in. by 14 in. when empty.

Sandbags should be three-quarters filled and the neck tied round with string provided for the purpose. The mouth should be tucked under when the bag is laid, and the corners tucked in. The sandbag should measure 20 in. × 10 in. × 5 in. when laid.

Sandbags are used for revetments, loopholes, etc. They are issued in bales of 250, weighing 96 lb.

8. **Sacks.**—Grain bags or sacks which may be available on service can be substituted for sandbags.

They usually contain 2 bushels (2½ cu. ft.) of grain. If used for field defence, they should not be more than half filled, otherwise they are too heavy to handle easily.

9. **Spikes** are large nails used for joining heavy timbers. A hole for the spike must be bored, with an auger of a length equal to the length of the spike from below the head of the commencement of the taper. The spike is driven in with a sledge-hammer, so that its chisel end is across the grain of the wood, otherwise the wood will split.

10. **Expanded metal,** commonly called XPM, is mainly used for revetting frames. It is made in sheets 6 ft. 6 in. long by 3 ft. wide. Weight, 8½ lb. It is usually issued in cases of twenty sheets.

11. **Corrugated iron** is used for revetting trenches and for roof shelters. It is used in sheets 6, 7 and 9 ft. long by 2 ft. 2 in. wide, and weighing, respectively, 16, 18 and 28 lb.

12. **Plain wire.**—Mainly used for binding purposes and in anchorages. It can be used for wire obstacles if barbed is not available. No. 14 standard wire gauge wire is issued in coils weighing 28 lb. and 56 lb.

13. **Canvas, hessian.**—Used behind wire-netting frames in revetting and for screens. Issued in rolls 110 yd. long, 36 ~~28~~ in. wide, weighing ~~130~~ lb.70

14. **Scrim.**—A light, coarse, very open-meshed canvas material.

15. **Hurdles.**—These are used for revetments and hutting. They are usually made 6 ft. long and 3 ft. wide. Six strong rods are driven into the ground about 10 in. apart. Then rods of brushwood are pressed down between them so that each rod first comes in front of and then behind an upright. When the hurdle is ready it is bound with plain wire at top centre and bottom to hold it together. Hurdles can also be made of XPM.

16. **Fascines** are long bundles of brushwood tightly packed and bound together. They are used for foundations for roads in marshy ground and for steps. The brushwood is laid on trestles and is then bound with wire at intervals of 18 in. The fascine " choker " for binding is put round the bundle, which is compressed by men pulling on the long ends of the handles. The fascine is then bound with wire close to the choker.

17. **" A " frames.**—" A " frames are of wood specially made for revetting or repair of trenches (Chapter XI). They would only be issued for defences of a semi-permanent character. A small " A " frame weighs 30 lb. (Plate 1, Fig. 1).

18. **Trench-boards.**—Trench-boards are wooden gratings of dimensions shown on Plate 1, Fig. 2. They are used to give a firm footing in trenches—usually used in combination with " A " frames, and on overland tracks. A trench-board weighs 35 lb.

19. **Wire-netting** is used in specially made revetting frames which, with canvas behind them, are used in revetting sand. It is also used for screens in concealment work and in constructing roads over sand.

Issued in rolls of 50 yd., 3 ft. wide; weight, 80 lb.

20. **Tracing tapes** have many uses, *e.g.* for tracing trenches, marking tracks, lines of wire obstacles, etc.

21. **Materials and tools used in wiring.**—

i. *Pickets* :—

(*a*) Screw pickets (Plate 9) are very useful when close to the enemy, as they can be screwed into the ground without making any sound. They are also easy to carry. When the ground is hard, holes have to be made for the pickets. This can be done by using the iron heads of picks.

They are made with loops which simplify the fixing of the wire.

There are two types of pickets—long and short.

(*b*) Wooden pickets have to be hammered in with mauls, which is a noisy operation. They are thick and easy to see. They are more likely to be available in mobile warfare than screw or iron ones.

(*c*) Angle iron pickets have to be hammered in with iron hammers, which is very noisy. They are strong and durable.

ii. *Barbed wire.*—There are two kinds of barbed wire :—

(*a*) Heavy wire—No. 12½ S.W.G., issued in coils of 130 yd., weighing 28 lb. a coil.

(*b*) Light wire—No. 14 S.W.G., issued in coils of ~~185~~ 176 yd., weighing 28 lb. a coil.

iii. *Windlass sticks.*—Every man of a wiring party must carry a short stick, or a piece of ½-in. round iron, 2 ft. long, called a windlass stick. These are necessary for :—

(*a*) Screwing in pickets.

(*b*) Running out coils of barbed wire.

(*c*) " Windlassing " wire.

iv. *Gloves and aprons.**—Quickness in wiring depends very much on the ability of men to handle the wire. Men who have much practice in wiring do not use gloves, but seize the wire boldly as though it were a rope.

Gloves save the hands from being scratched, but are likely to catch the wire. If used they should be without fingers. They should be attached to the body by a string or tape joining the gloves and passed round the back of the neck.

Leather aprons save the clothing of men running out the coils of wire and may be used in training.

v. *Wire cutters* (*cutting pliers*).—These should be tied to the belt with a long string, otherwise in the dark they are certain to be lost.

* These are not articles of issue.

vi. *Jumping bars.*—These are only required for making holes for pickets when the ground is very hard. For night work they should be wrapped with string or two thicknesses of canvas to prevent noise. In moderately hard ground pick heads may be used instead.

7. *Provision of tools and materials in peace and war*

1.—i. *Peace.*—The tools and stores provided for the peace instruction of troops, in field engineering, are as laid down in Equipment Regulations, Part I.

ii. *War.*—The war scales of tools and stores are given in the various sections of Equipment Regulations, Part II, and in Mobilization Store Tables (Army Form G 1098) or War Equipment Tables. A table showing tools carried in the field is given in Appendix II.

2. In the simplest form of work, the proportion of tools in Appendix I will give a guide as to what is required in ordinary circumstances.

8. *Tool and digging drill*

1. General.—

i. The pick and shovel cannot be used to the fullest advantage in war without careful and frequent practice in peace.

ii. The sequence of instruction is as follows. The soldier should first be taught to handle and march with his pick and shovel, then the motions of picking and shovelling, and then to dig small tasks. Later he should dig, under supervision, a full task of trench work.

iii. The purpose of the drill given in the following sections is to teach the soldier to use his pick and shovel in such a way that he will get the best value out of his tools with the minimum of fatigue.

iv. The soldier must understand that the whole secret of this drill is to maintain an even, rhythmic motion. He must never be allowed to make sharp movements, and pause between the movements, as in rifle exercises, otherwise he will rapidly become tired.

2. Issue of tools.—

i. Tools are issued from stores in one of the following ways :—

(i) When those in charge of the stores have little time, the picks are stacked in one heap and the shovels in another, with a narrow passage between heaps. The men pass in single file between the heaps, taking up a pick with the left hand and a shovel in the right.

(ii) When those in charge of the stores have time to lay out the tools and know the number coming, the tools are laid out in sets, shovel on the right, helves 18 in. apart, irons of both to the front, point of the blade of the shovel in line with the pickhead, the sets at one pace interval, those for the rear rank are at three paces distance. The party can then be marched in file, straight on to its tools.

3. Tool drill.—

i. *Falling in with tools* (Plate 2).—The soldier will fall in at the trail, pick in the left hand, shovel in the right, irons of both to the front, point of the pick downwards and the face of the blade of the shovel inwards.

ii. *Grounding and taking up tools.*—

" Ground tools."

Take a short pace forward with the left foot, bend down and place the tools quietly on the ground, irons of both to the front, pick on the left, shovel on the right, face downwards, the point of the blade in line with the pickhead. The left hand to be 3 in. in front of the left toe as it places the pick on the ground. Then return smartly to the position of attention.

" Take up tools."

Take a short pace forward with the left foot, bend down, take up the tools and return to the position of attention, tools at the trail.

Common mistakes.—The usual mistake is to place tools too far forward. The result of this is that men have to bend too far down, and if they have rifles slung and are wearing equipment, their rifles fall over their heads. The body should be kept as erect as possible and the left hand be put quite close to the left toe, as ordered above.

iii. *Marching with tools.*—As in war nearly all marching with tools is done by night, and near the enemy, men must learn to handle them so that they make no noise. This point must be carefully watched in practising the following drill :—

" Right turn."

Drop the head of the pick and raise the blade of the shovel (Plate 2), turn to the right and bring the tools back to the trail ; if in file at close order, the handles should be allowed to splay outwards.

" Left turn."

As above, except that the turn is to the left.

" About turn."

Drop the head of the pick and raise the blade of the shovel, turn about and bring the tools back to the trail.

" Form fours."

Each man will drop the head of his pick and raise the blade of his shovel, and the left files will move as in squad drill, each man keeping his tools in this vertical position until the command " Right " or " Left " is given. On the completion of the right or left turn the tools will be brought back to the trail.

When marching at " Attention " tools are always carried at the trail (*see* sub-para. i, above).

When marching at ease the tools may be carried over the shoulder.

4. **Digging drill.—**

i. *Pick drill* (*see* Plates 3 and 4). The words of command for using the pick are given in the following sub-paragraph.

ii. *Picking.*—Right hand forward ; right foot forward.

" Ready."

Turn half left and carry off right foot to right. Body evenly balanced on both feet. Pick horizontal in front of body. Both arms loose. Right hand about 4 in. from pick-head. Left hand at small end of helve.

" Raise."

Fix eyes on point to be struck. Raise pick over right shoulder, keeping right upper arm horizontal, centre of pick directly over right shoulder, left arm slightly bent across front of body. Right hand moves slightly towards left, weight of body on rear foot.

" Strike."

Eyes on mark. Holding firmly with left hand, strike downwards, allowing helve to slip through right hand. At the moment of striking the ground both hands grip tightly, weight of body coming on to forward hand.

" Break."

Force small end of helve upwards and move forward hand towards pickhead.

" Rake."

Rake the loosened earth towards feet by pulling pick back with both hands. Weight of body on rear foot.

" Raise."

Straighten the forward knee and trunk and continue ; if necessary, the " Rake " may be repeated before " Raise " by carrying the pick forward and raking.

The drill is continued by the repetition of the commands **" Raise," " Strike," " Break," " Rake,"** as necessary. It is important to teach a regular rhythm. The rate should be from 28 to 30 strokes a minute for periods of from 15 to 30 seconds, followed by a short pause, during which, if it is desired to continue work with the shovel, the pick will be grounded and the shovel taken up.

iii. *Picking.*—Left hand forward ; left foot forward ; the position of feet and hands and the action are reversed.

iv. *Shovel drill* (Plates 5 and 6).—The words of command for using the shovel are given in the following sub-paragraph.

v. *Shovelling.*—Right-handed. For throwing to left and front.

" Ready."

Turn half right and advance left foot to left near loosened earth. Body balanced on both feet. Right hand on " T " with thumb round. Left hand grasping bend of shovel, palm up.

" Swing and fill."

Swing shovel back with weight of body on rear foot ; left arm straight and left hand near right knee. Right arm to incline shovel towards base of loosened earth. Swing body and shovel forward so that the pan slides along base, bending left knee, weight of body behind thrust.

" Handle low."

Depress " T " piece of helve to free shovel load from pile of earth.

" Swing and throw."

Swing shovel backwards, just clear of ground, until pan is over right toe. Weight of body on rear foot.

Cast the load away by a forward, upward, and slightly lateral swing, bringing weight on forward foot, left arm straight, shovel sliding freely through forward hand, right arm directing shovel, the body straightened according to height of throw.

Aids.—For heavy soil or rough base. Place left knee against left forearm and the inside of right thigh just above the knee against the back of right hand. Bend both knees with a crouching movement and bring the weight of body behind the thrust.

The drill is continued by the repetition of the commands **" Swing and Fill," " Handle Low," " Swing and Throw."** It is important to teach a regular rhythm, and the rate should be from 18 to 20 throws a minute without aids, and 16 to 18 with aids. The period should be from 15 to 30 seconds, followed by a short pause during which, if it is desired to continue work with the pick, the shovel will be grounded and the pick taken up.

vi. *Shovelling left-handed—For throwing to right and front.*—The position of feet and hands and action are reversed.

5. Points for instructors.—

i. Men should be taught to use the pick and shovel equally well with either hand in front. Unless they can do this they cannot work facing the front of their trench and will be dangerous to those working near them. Nor will they be able to throw the earth as required to right or left. Moreover, by changing hands they use different muscles and so get rest. Men must practise throwing earth in one lump on the place where it is to go.

ii. Individual instruction by numbers should not be complicated by an endeavour to excavate a trench at the same time. The soldier will have enough to do learning the correct motions without working to dimensions.

iii. Soldiers should not be placed closer together than two paces while carrying out tool drill, otherwise they cannot have free play for their tools.

iv. The energy expended in digging is reduced by half if the work is done with a clean " face " and a clean " base."

To illustrate this, let the soldier strike his pick into hard flat ground and he will find that only a handful of earth comes out.

Then let him strike his pick about 9 in. back from the edge of a vertical " face " of earth (Plates 3 and 4), and he will see that each stroke will break out several shovelfuls of earth. This shows that if a man arranges his work so as always to work against a " face " he will only use his pick once, while the man who has no " face " will use it twenty times.

v. Unless the " base," or the ground on which the man is standing, is kept clean and smooth and flat, the shovel will not slide along the ground under the loose earth, and the man will not get a full shovelful of earth.

The base should also be kept clear of loose earth, otherwise the man will tread it down, so that it has to be dug up again with the pick, and so duplicate his work.

vi. All ranks should be taught that when the earth is very hard and full of stones, they can help their arms by using their knees when filling the shovel. Plate 7 shows this. The left knee should be placed against the left forearm, if working with the left hand in front. Place the inside of the right leg just above the knee against the back of the right hand. Bend both knees and bring the weight of the body behind the thrust. The rate of working will be 16 to 18 throws a minute when doing this.

vii. When the ground is very soft the work can be taken out quicker without using the pick (Plate 7).

The shovel is driven into the ground by placing a foot on the shoulder of the shovel. If working with the left hand forward—that is, when throwing to the left—the left foot should be used for this. Work with a face as shown in this plate.

After pressing the shovel into the ground, the earth is broken away by pressing the handle downwards with the rear hand, then the earth is lifted and, with a swinging motion, is thrown out of the trench or pit.

It will be necessary to clean the base from time to time, as some loose earth will certainly fall out of the shovel.

viii. When digging wide trenches, the pick should swing towards the front of the task, otherwise there is danger of striking the man in the next task.

In a narrow trench all men should start work on the left of their tasks, and will face towards their right when using the pick so that they may not hit each other.

A man does most work in 4 hours if he rests for 2 minutes after every 8 minutes' work, and has a longer rest for 5 minutes at the end of 55 minutes.

ix. If the points given above are followed, a soldier should be able, in average soil, with a maximum throw of 12 ft. and maximum lift of 4 ft., to dig out of a trench the following amounts :—

In the first hour	...	30 cu. ft.
In the second hour	...	25 ,,
In the third hour	...	15 ,,
In the fourth hour	...	10 ,,
Total in 4 hours	...	80 ,,

(NOTE.—An average shovel load weighs 10 lb.)

The above figures apply to digging in daylight—by night the total may be decreased to 60 cu. ft. For general estimating, however, it is safer only to assume 60 cu. ft. by day and 50 cu. ft. by night.

x. *Intensive digging.*—When digging a position which has been captured in an attack, the number of tools availab'e will often be not more than 1 pick and 1 shovel to three men. Men should be practised in digging-in quickly with these numbers of tools. This may be done as a drill. Each man digs as fast as possible for 2 minutes, the other two men lying behind the trench. At the end of two minutes the instructor blows a whistle. The next man (No. 2) jumps into the trench and goes on with the work while No. 1 rests. After two more minutes No. 3 takes No. 2's place, and so on. Each man works as hard as possible for 2 minutes and rests 4 minutes. Men should be taught to work so hard for 2 minutes that they can work no longer without resting.

9. *Excavation of tasks*

1. **General.**—The method in which a task is excavated depends on circumstances.

If in proximity of the enemy each man must obtain cover by digging a pit, placing the excavated earth as a parapet on the side exposed to enemy fire. A pit measuring $3\frac{1}{2}$ ft. $\times$ $2\frac{1}{2}$ ft. is the smallest in which a man can use his pick and shovel.

When circumstances permit, he will start widening and lengthening the pit until his task (Plate 23) is completed.

2. **Commencement of digging.—**

i. If the trench is to be dug to the full section as shown in Plate 22, when the spitlocking to mark the front and rear edges of the trench has been done, the man will commence work by digging out a hole, 6 in. to 9 in. deep, across the back of his task, until the whole task has been taken out to this depth. He will then begin work again at the back, and take out a second layer in the same way, and so on till the trench is excavated to the full depth. The sides will then be sloped as described in paragraph 6, below.

All the time he will work as fast as possible, with his pick and shovel swinging towards the front and rear, so as not to hit the man in the next task.

ii. If, as will usually happen, the first task is only taken out to 3 ft. 6 in. broad (Plate 22, Fig. 2), there is no room to leave 9 in. on each side to make a proper slope (para. 6, below). The slope must therefore be judged by eye.

In this case the man will begin by excavating a piece of earth, 6 in. to 9 in. deep, across the left of his task. This will give him a face on his right, on which he must work, facing to his right or half right.

After completing the trench to this depth, he can then start again at the left-hand end.

3. **Length of task.**—The length of trench allotted to each man as a task, depends on the section of trench to be dug, and on the number of cubic feet given in a task.

The usual distance is 6 ft. The length of a task should never be less than 5 ft., or men will hit each other. Even in a 6-ft. task, men will often have to wait till the next man has finished a part of his work.

If possible over 6 ft. should be given.

A 6-ft. task gives $49\frac{1}{2}$ cu. ft. in the smallest trench (*i.e.* 3 ft. 6 in. wide at top, 2 ft. wide at bottom, and 3 ft. deep), $7\frac{1}{2}$ ft., or three paces, gives 62 cu. ft.

4. **Work on sides of a traverse.**—The men working on the sides of a traverse have a more difficult task. If they throw their earth straight on to the traverse, it will be very high and there will be a gap in the parapet at each end of the firebay.

The men working on the sides of traverses must be taught to throw their earth towards the front of the traverse.

This is difficult, even if men are trained to do it. If possible, special men should be provided for shovelling the earth forward.

5. **Communication trenches.**—In digging communication trenches the earth should first be thrown up on that side of each length of trench from which the enemy bullets are most likely to come.

6. **Sloping the sides of a trench.—**

i. Sloping the sides should be left till the excavation has been done. Plate 8, Fig. 2, shows what happens if a man tries to make the slopes by eye. Fig. 1 of the same plate shows the section of a trench, 6 ft. deep, of which the right-hand side slopes at 4/1 and the left-hand side 3/1.

The first task is 3 ft. deep, sufficient space is then left on each side to allow for the slope, and the part marked A is dug first, with vertical sides.

When this is finished the parts marked B.B. are dug out. This gives the sides the proper slope. The man doing the next task will similarly dig out the part marked C with vertical sides, and afterwards excavate the parts marked D.D.

ii. The amount of space to be left on each side—for the various slopes—is calculated as follows (Plate 8, Fig. 1). Taking a slope of 4/1.

This means for every 4 ft. of depth, 1 ft. must be left; or for every 1 ft. of depth, ¼ ft. must be left.

Therefore, for every 3 ft. of depth, ¾ ft. must be left.

In the same way for a slope of 3/1, a width of 3/3 = 1 ft. must be left, and in Plate 8, Fig. 3, which shows a slope of 2/1, a width of 3/2 ft., or 1 ft. 6 in., must be allowed for every 3 ft. of depth.

iii. Plate 8, Fig. 3, shows how to begin sloping the sides. Each man should begin by cutting very carefully a strip like the part marked W.X.Y.Z. This will act as a profile and help him to get the rest of the slope right.

iv. The provision of a template is of great assistance. Amdt. 1 June, 1934

CHAPTER IV

ORGANIZATION OF WORK

10. *General considerations*

1. General.—

i. Speed in construction of field works in close proximity to the enemy is always essential. Time, labour, tools and materials available will invariably be insufficient to meet all demands. Work will often have to be carried out in darkness.

It is therefore essential that all ranks should be familiar with the general principles, methods and responsibilities involved in the correct organization of work.

ii. The case which will be chiefly considered in the following sections is that in which only a limited time is available for work on a defensive position.

iii. The underlying principles and responsibilities remain the same whether work is on a large or small scale, whether it is carried out in contact with the enemy or not, and whatever time is available.

2. Object of organization.—

i. A system of organization of work should ensure :—

Control.
Speed.
Efficiency (*i.e.* economical use of the resources available).

ii. The more centralized the control the greater will be the efficiency in getting full value out of resources available. Speed will often be so important, however, that efficiency will have to be sacrificed and control largely decentralized.

Control is obviously best attained by adhering to normal military organization. Complete sections, platoons, companies or units should be employed on particular tasks or portions of the work.

iii. Speed depends largely on training and adhering as closely as possible to a well-known procedure and drill in the organization and execution of work.

iv. Efficiency depends chiefly on the rapid issue of adequate orders, resulting in the correct quantities of labour, tools and materials being available at the right time and place.

11. *Control of work*

1. **General.**—Except in the case of very small works there are three links in the chain of control :—

i. The formation or unit commander who has ordered the work to be done.
ii. The officer in charge of the work—appointed by the formation or unit commander.
iii. The officer in command of the working party.

2. **Summary of duties.**—The duties of officers concerned in the initiation and execution of field works are summarized below :—

i. *Formation or unit commander ordering the work to be done.*
(*a*) Reconnaissance.
(*b*) Priority of work.
(*c*) Instructions to officer in charge of work.
(*d*) Arrangements for provision of men, tools, materials and transport.
(*e*) Arrangements for control and continuity of work.
(*f*) Provision of covering party if necessary.

ii. *Officer in charge of the work.*
(*a*) Detailed reconnaissance.
(*b*) Design.
(*c*) Estimates.
(*d*) Marking out the work.
(*e*) Guides for working parties.
(*f*) Explanation of the work to officers in charge of working parties.
(*g*) Correct execution of the work.

iii. *Officer in command of working party.*
(*a*) Explanation of the work to his subordinates.
(*b*) Allotment of tasks to, and disposal of, his men on the work.
(*c*) Ensuring that his men have the necessary tools and materials.
(*d*) The diligence of his men.
(*e*) The discipline of his men and observance of orders regarding lights, smoking and silence.
(*f*) The execution of the work in accordance with the instructions of the officer in charge of the work.
(*g*) Handing over of work, tools and materials to the next party, or as instructed by his commander or by officer in charge of the work.
(*h*) Withdrawal of his party when the work is completed.
~~(*i*) Action in the event of casualties.~~

3. In the event of serious casualties being incurred by a working party, the *senior officer on the spot* will be responsible for deciding whether the working party should be withdrawn temporarily or whether an attempt should be made to carry out the task at all costs. Amdt. 2 Mar., 1937

If heavy casualties are anticipated, the commander who orders the work should give definite instructions as to its urgency.

1. The preliminary reconnaissance will be carried out by the formation or unit commander ordering the work to be done.

The officer in charge of the work will, if possible, accompany him. This will result in decisions and orders to the officer in charge of the work on the following points :—

i. Approximate siting and nature of the work.
ii. Approximate resources in time, labour and materials available.
iii. Outline of organization for the execution of the work.
iv. Provisional priority of the work.
v. Covering parties, if required.

2. The officer in charge of the work will then make a detailed reconnaissance of his task. The points to be considered in this reconnaissance will include :—

i. *The work to be done.*—Its place, nature and quantity.
The exact position of every portion of the work which is to be done must be decided. Time may be saved if the work is actually marked out as the reconnaissance proceeds. (*See* Sec. **14**, **6**, and Appendix III, for details of tracing parties, which should accompany officer in charge of work.)
The definition, by natural or artificial marks, of areas to be cleared for improvement of fields of fire or view requires particular care, especially if work has to be carried out at night.

ii. *The design* of the work, including the most suitable type of work (*e.g.* weapon pit, breastwork, etc.).

iii. *Labour.*—What labour is required : its quality and quantity. Appendix I will be an aid to this calculation, which should include a reserve for unforeseen contingencies.

iv. *Tools and materials.*—The nature and quantity required (Appendices I and II), whence obtained, and how brought to selected places.

v. *Time.*—When work may be begun and how long it will take to complete.

vi. *Rendezvous, routes and guides.*—The rendezvous should be on the route to the work. It should be easily

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i. The
work to be done.
ii. The officer in charge of the work—appointed by
formation or unit commander.
iii. The officer in command of the working party.

2. **Summary of duties.**—The duties of officers concerned in the initiation and execution of field works are summarized below :—

i. *Formation or unit commander ordering the work to be done.*
(*a*) Reconnaissance.
(*b*) Priority of work.
(*c*) Instructions to officer in charge of work.
(*d*) Arrangements for provision of men, tools, materials and transport.
(*e*) Arrangements for control and continuity of work.
(*f*) Provision of covering party if necessary.

ii. *Officer in charge of the work.*
(*a*) Detailed reconnaissance.
(*b*) Design.
(*c*) Estimates.
(*d*) Marking out the work.
(*e*) Guides for working parties.
(*f*) Explanation of the work to officers in charge of working parties.
(*g*) Correct execution of the work.

iii. *Officer in command of working party.*
(*a*) Explanation of the work to his subordinates.
(*b*) Allotment of tasks to, and disposal of, his men on the work.
(*c*) Ensuring that his men have the necessary tools and materials.
(*d*) The diligence of his men.
(*e*) The discipline of his men and observance of orders regarding lights, smoking and silence.
(*f*) The execution of the work in accordance with the instructions of the officer in charge of the work.
(*g*) Handing over of work, tools and materials to the next party, or as instructed by his commander or by officer in charge of the work.
(*h*) Withdrawal of his party when the work is completed.
(*i*) Action in the event of casualties.

The officer in command of the working party may be senior to, and belong to a different arm from, the officer in charge of the work. This must never be allowed to affect their loyal co-operation in observance of their respective responsibilities.

12. *Reconnaissance*

1. The preliminary reconnaissance will be carried out by the formation or unit commander ordering the work to be done.

The officer in charge of the work will, if possible, accompany him. This will result in decisions and orders to the officer in charge of the work on the following points :—

i. Approximate siting and nature of the work.
ii. Approximate resources in time, labour and materials available.
iii. Outline of organization for the execution of the work.
iv. Provisional priority of the work.
v. Covering parties, if required.

2. The officer in charge of the work will then make a detailed reconnaissance of his task. The points to be considered in this reconnaissance will include :—

i. *The work to be done.*—Its place, nature and quantity.
The exact position of every portion of the work which is to be done must be decided. Time may be saved if the work is actually marked out as the reconnaissance proceeds. (*See* Sec. **14**, **6**, and Appendix III, for details of tracing parties, which should accompany officer in charge of work.)
The definition, by natural or artificial marks, of areas to be cleared for improvement of fields of fire or view requires particular care, especially if work has to be carried out at night.

ii. *The design* of the work, including the most suitable type of work (*e.g.* weapon pit, breastwork, etc.).

iii. *Labour.*—What labour is required : its quality and quantity. Appendix I will be an aid to this calculation, which should include a reserve for unforeseen contingencies.

iv. *Tools and materials.*—The nature and quantity required (Appendices I and II), whence obtained, and how brought to selected places.

v. *Time.*—When work may be begun and how long it will take to complete.

vi. *Rendezvous, routes and guides.*—The rendezvous should be on the route to the work. It should be easily

recognizable and, if possible, near cover. If routes are across country, they should, when possible, be marked. Guides should know the rendezvous and the routes by which working parties will approach.

vii. *Transport.*—What kind of transport should and can be used.

13. *Preliminary arrangements*

1. **General.**—If time is short responsibility must be decentralized and more must be left to the initiative of subordinates.

2. **Tracing.**—All work should be marked out, before the arrival of the working party, by pegs, pickets, tracing tapes or spitlocking, etc. This applies not only to trenches but to wire entanglements, emplacements, areas to be cleared, tracks, etc. Tracing will generally be done under the personal supervision of the officer in charge of the work. (*See* Sec. **37**, and Appendix III.)

3. **Estimates.**—

i. Estimates are prepared, generally by the officer in charge of the work, as a result of the detailed reconnaissance described in Sec. **15**. A complete detailed estimate should deal with the following points :—

(*a*) Labour.
(*b*) Time.
(*c*) Tools.
(*d*) Materials.
(*e*) Carrying parties.
(*f*) Transport.
(*g*) Any other requirements, such as guides, covering party, etc.

Appendix IV (Load tables) should be used as a basis for estimating.

ii. Time, labour, tools and materials are interdependent factors.

It is evident that the officer making an estimate must first note approximately the resources likely to be available before he can proceed intelligently with his estimate.

iii. If local materials are to be used allowance must be made for the time and labour required to collect, prepare and distribute them.

iv. No more men should be asked for than are absolutely necessary.

4. **Demands.**—

i. Having prepared detailed estimates for the portions of the work to be commenced at once, if not for the whole work, the officer in charge of the work should then submit his demands for labour, etc., to the authority laid down by the officer ordering the work.

ii. It will be noted that in the demand the actual number of men required is stated. It will be the duty of the formation or unit supplying the working party to make up this number by detailing complete units, companies, platoons or sections in accordance with the actual strength of units at the time.

14. *Organization of working parties and allotment of resources and tasks*

1. **General.**—The efficient employment of working parties depends chiefly on :—

i. Discipline.
ii. Allotment of suitable tasks, tools and materials.

The first is the responsibility of the officer in command of the working party, and the second depends primarily on accurate estimating by the officer in charge of work, but also on intelligent control by the officer in command of the working party during the execution of the work.

2. **Reliefs.**—Whenever possible each relief should arrive complete with all tools required for work and should return them on conclusion. It is impracticable to hand over tools direct from one relief to the next in the dark. In such cases, if separate tools for each relief are not available, the tools must be dumped in one place for distribution to the next relief on arrival.

3. **Task work.**—The main advantage of task work over time work lies in the moral effect due to :—

(*a*) knowing what is to be done ;
(*b*) knowing that there is no chance of going until it is done.

i. In most work, especially of a straightforward nature like digging or wiring, better results are generally obtained by task work than by time work.

ii. It is essential, however, that tasks should be set fairly. They should be so calculated that the average man can complete them just inside the period of work being considered, which is generally 4 hours. The nature of the soil should be carefully considered in setting the task.

iii. If possible a 6-ft. measuring rod should be carried by each platoon or section commander. In the absence of measuring rods, pick helves, which are 3 ft. in length, can be used. ~~A template, or gauge, is useful if obtainable. It is a light framework of wood made to give the outline of the section of trench required.~~

iv. The system works best when tasks are not allotted to individuals, but to small parties, such as sections.

v. When working with reliefs on task work care must be taken that all parties of one relief have completely finished their tasks before the arrival of the next relief, so that the latter are not kept waiting. A short interval of time should be allowed between the estimated time of completion of any relief and the arrival of the next relief.

4. Time work.—

i. This system should not be used unless task work is impracticable.

ii. Time work may be used when the local conditions are unknown or very variable.

iii. The amount of work which the officer in charge of the work expects to be completed must always be indicated to the officer in command of the working party.

iv. In fixing the length of reliefs on time work (or estimating tasks in task work) consideration must always be given to the urgency of the work, to the distance the troops have to march to and from the work, and their condition.

5. Tools.—

Except for small works additional tools are always required over and above those forming part of unit equipment.

The infantry brigade tool reserve (Appendix II) is designed to meet this need, and if further tools should be required a demand can be made on the divisional tool reserve (Appendix II) which is carried by the field park company, R.E.

6. Tracing.—

i. If tracing cannot be done by day, it should be done at dusk while it is just light enough to ensure that the trace is suitable to the ground. Spitlocking is unsuitable for work which has to be carried out by night.

When tracing by night, direction should be frequently checked by compass or other means.

ii. The front " cutting line " of a fire trench is the line which must be marked. It is an advantage to mark the back line as well.

iii. Care must be taken that tracing marks of work which is to be concealed do not disclose the work to enemy observers.

iv. A tracing party should rehearse its work beforehand if possible, as this will add to the speed of the work.

v. The detailed organization of a tracing party is given in Appendix III.

7. Extension of working parties for digging.—

i. It is important that, on arrival at the site of work, the working party should be distributed along the line of work without noise or confusion. As this may often take place during the hours of darkness, practice is essential. The nature of work and task must be explained to the party beforehand.

ii. The following is the procedure when a working party is extended, starting from the left of the line of work :—

(*a*) An officer or N.C.O. will stand at the left of the line on to which the party is to be extended, prepared to pace or measure out each man's work.

(*b*) The party will be formed in single rank at a convenient distance from the line and marched up in single file, at right-angles to the line, until the leading man is within two paces of the officer or N.C.O. charged with pacing out the tasks. Tools will be at the trail, and rifles slung.

(*c*) The N.C.O. will then indicate the left of the task, and the leading man will step forward and drive the point of his pick into the ground at that spot, helve to the rear, and lay his shovel along the line of his task, blade to the left, face downward.

(*d*) The N.C.O. will pace along the line and show the second man his task ; this man will wheel to the right until opposite his task, then wheel to the left and carry on as detailed for the leading man. The remaining men repeat this.

(*e*) If extending from the right the procedure is similar.

All men must know the correct division of a fully developed fire trench for task work (Plate 22).

(*f*) As soon as the last man of the party has reached his task, each man will unsling and ground arms, six paces in rear of his task, and commence work.

iii. When working in reliefs the second and following reliefs should not be allowed to move along the half-dug trench, unless it is too dangerous to move across the open.

paragraph iv. An alternative method of extension suitable in the

v. Yet another method is as follows :—The leading man goes right through to the far end of the work and the remainder space themselves out behind him along the line of the work. This method is not quite so rapid but is well suited for work in close proximity to the enemy. Amdt. 1 June, 1934

tools or stores to be carried should be arranged in loads before the arrival of the party. The men must be told the composition of the load, before they start collecting them. At the end of the journey the loads must, according to instructions, be put down so as to form an orderly dump, or distributed at the points on the work where they are needed.

ii. If casualties are probable and various types of store are being carried, the stores of any one kind should be distributed among different individuals, or different parties if more than one party is being used. Otherwise severe casualties to one party carrying, for example, all the long pickets, would seriously hamper the progress of the work.

9. Arms and equipment.—

i. When working in close contact with the enemy, the commander of the party may decide to work with arms slung ; this greatly hinders the work and should not be done unless there is danger of attack. In the forward area it is generally sufficient if each man lays out his arms and equipment close at hand, for use in an emergency.

ii. When the work is below fire-step level and there is danger of an attack, arms should be laid on the parapet, and all the earth being excavated should be thrown on the parados.

iii. In rear areas arms and equipment may be left under a guard in a convenient spot.

iv. When the enemy is likely to use gas, anti-gas respirators will be worn in the " alert " position.

10. Modifications.—

The procedure given in this section must be modified to meet all conditions. Only thus can work be properly organized.

(To be read in conjunction with Infantry Training, 1937, Sec. 74, 8.)

CHAPTER V

GENERAL CONSIDERATIONS REGARDING PROTECTIVE WORKS

15. *Scope of protective works in defence*

The scope of protective works in defence will be considered under the following heads :—

i. *Concealment.*—(Chapter VI.)
ii. *Observation.*—(Chapter VI.)
iii. *Communications.*—(Chapter VI.)
iv. *Obstacles.*—(Chapter VII.)
v. *Protection.*—(Chapter VIII.)
vi. *Sanitation and comfort.*

16. *Priority of work*

1. There will **never** be enough time, labour or material available to carry out all the useful work demanded. Careful selection of the work to be done will **always** be necessary, and much will depend on the efficiency of previous training in the rapid organization and execution of work.

2. As early as possible a comprehensive scheme of development must be planned, from which a priority list of work to be done must be drawn up.

It is necessary to concentrate in the first instance on providing the essential minimum of each type of work which will be most valuable to the defence.

3. Priority in any particular case will depend on the decision of the commander, and no hard-and-fast rule can be laid down, but the following order of priority may be taken as a general guide :—

i. *Siting of weapons and O.Ps.*
ii. *Improving communications.*
iii. *Clearing and improving the field of fire.*
iv. *Digging fire positions, constructing machine-gun positions and observation posts.*
v. *Creating obstacles.*
vi. *Constructing shelters.*
vii. *Completing the fire positions and connecting them up.*
viii. *Completing the communication or connecting trenches.*

4. Field defences are a means to an end and must be constructed to conform to the tactical plan. Well-planned field defences develop the fire effect of the defender's weapons and restrict that of the attacker's weapons. Skilfully used, they enable the commander to reduce the proportion of his force in actual contact with the enemy and to increase his reserves.

iv. An alternative method of extension, suitable in the vent of heavy fire from the enemy, is for the men to be xtended in rear of the line to be dug and marched straight n to the work, taking care to keep the proper interval.

8. **Carrying parties.—**

i. These must be organized as for working parties. The tools or stores to be carried should be arranged in loads before the arrival of the party. The men must be told the composition of the load, before they start collecting them. At the end of the journey the loads must, according to instructions, be put down so as to form an orderly dump, or distributed at the points on the work where they are needed.

ii. If casualties are probable and various types of store are being carried, the stores of any one kind should be distributed among different individuals, or different parties if more than one party is being used. Otherwise severe casualties to one party carrying, for example, all the long pickets, would seriously hamper the progress of the work.

9. **Arms and equipment.—**

i. When working in close contact with the enemy, the commander of the party may decide to work with arms slung; this greatly hinders the work and should not be done unless there is danger of attack. In the forward area it is generally sufficient if each man lays out his arms and equipment close at hand, for use in an emergency.

ii. When the work is below fire-step level and there is danger of an attack, arms should be laid on the parapet, and all the earth being excavated should be thrown on the parados.

iii. In rear areas arms and equipment may be left under a guard in a convenient spot.

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CHAPTER VI

CONCEALMENT, OBSERVATION AND COMMUNICATIONS

17. *Concealment*

1. General.—In siting and constructing field defences, concealment is of the greatest importance; its absence can be replaced to some extent in permanent defence works by the solidity and strength of their construction, but this does not apply to field defences.

2. Enemy observation.—

i. Concealment must always be directed against two dangers:—

(*a*) *Air observation.*—Visual and Photographic.
(*b*) *Ground observation.*

ii. The importance of concealment from air observation should not be allowed to detract from the necessity for concealment from ground observation.

It must be remembered that what is concealed from the ground observer may be quite apparent to the man or camera in the air, and *vice versa.*

3. Methods.—

i. The chief ways of obtaining concealment are:—

(*a*) *Screening.*
(*b*) *Blending.*
(*c*) *Deceiving.*

ii. *Screening.*—This involves careful siting of works so as to make use of natural features, such as folds of the ground, hedges, trees and woods.

A screen need not be solid to be effective, provided it has a background. Properly sited it need not restrict the view of the defenders, yet may prevent the enemy from seeing beyond it.

Dummy screens of canvas in unoccupied positions have been used with great effect to draw hostile artillery fire.

iii. *Blending.*—This is true concealment. It involves primarily the avoidance, as far as possible, of straight lines, unnatural colours, tone, shadows or absence of shadow, or repetition of stereotyped works.

Although trenches can never be completely concealed except by natural or artificial screening, it is possible by blending, to

make them much less conspicuous to ground observation. Against trained air observation, it is only possible to conceal a limited number of small and important works, such as emplacements and observation posts. Where trees or buildings are not available, the use of artificial overhead screening is necessary. This will not always be possible in mobile warfare.

iv. *Deceiving.*—When possible it is of great advantage to construct dummy trenches, machine gun positions, battery positions, etc. To be effective, dummies must be sited in probable positions, they must reproduce normal evidences of occupation, must appear to have been intended to be concealed, and must be complete, *e.g.* tracks must be maintained. Dummy trenches make it difficult for the enemy to determine which trenches are actually occupied. They need only be 12 to 18 in. deep, and branches of trees laid in them increase the shadow and appearance of depth. Dummy trenches must be the same width as the trenches they represent, and the limited amount of spoil obtained from them must be spread thinly to cover approximately the same area as would be covered by spoil if the trenches were real.

v. In the following paragraphs some hints are given as to the application of these methods of concealment to protective works; in practice each case must be treated on its merits, and as much done to promote concealment as circumstances allow.

4. Concealment from air observation.—

i. Efforts must be directed primarily against photography, as, except for movement and differences of colour (as opposed to tone), anything which will deceive the camera will deceive an observer flying at normal heights.

ii. *Tone.*—Objects in photographs appear black or white or various tones of grey. The tone depends to some extent on colour; for instance, in a photograph, smooth, but not glossy, surfaces of various colours appear as follows:—

White or yellow appear white.
Orange or green appear light grey.
Red or blue appear a darker grey.
Black appears black.

Tone is, however, less affected by colour than by texture, *i.e.* the amount of shadow in a surface and the degree to which it reflects or absorbs light. Smooth or textured surfaces of the same colour will appear in photographs correspondingly lighter or darker in tone. It is also evident that a photograph

of an area in brilliant sunshine will include a wider range of tone from white to black than a photograph of the same area on a dull day.

It is therefore desirable to make the tone of the object the same as that of the background as it appears in an air photograph. This applies particularly to spoil from an excavation. When in doubt, it is better to err by making the screen or camouflage material too dark rather than too light in tone.

iii. *Shadow.*—Roads and tracks which are clear of grass contain no shadow, and therefore appear white. Houses and trees appear nearly white where the sun is shining on them, and black where shaded. Newly ploughed land and new earthwork such as the parapets of trenches appear nearly white, because the surface is smooth and contains few small shadows. Long grass and crops appear dark, as each blade and stalk throws a shadow. If, however, the grass or crops are leaning over, they will be reflecting a great deal of light, and will appear lighter in tone. The cast shadow is often more conspicuous than the object itself. An object may be sited so that it and its cast shadow are within the cast shadow of some natural feature, or so that its cast shadow is absorbed by some irregular object, such as a hedge.

iv. *Interpretation of air photographs.*—Interpretation chiefly depends on comparison of photographs taken at short or long intervals of time, on observation of the development of tracks or other signs of occupation in the vicinity of suspicious objects, and on the shape of shadows in photographs taken at various elevations of the sun. Any form of regularity, foreign to nature, shows up conspicuously in photographs.

v. *Overhead screens.*—When circumstances permit the use of overhead screens, it must be remembered that to be effective they must be in a position, at any rate during daylight, from the beginning of work, as otherwise a single photograph or visual observation may disclose position of the work to the enemy. If possible the perimeter of the screen should be irregular and free from straight lines. Any pattern of colour or material in the screen designed to promote concealment should be irregular and bold, as the effect of small patterns or small irregularities will be nullified in the greatly reduced scale of the photograph. Screens will generally be made of hessian or scrim canvas, sacking, or wire or other netting. They may be painted, tarred, or threaded with hay, grass or foliage according to the depth of tone (or shadow) required to blend with their surroundings.

Overhead screens should be flat and as low as possible.

Any shadow likely to be cast by the erection of covers must be taken into account, and screens should generally be continued at a slope to the ground level. The change in colour as freshly cut vegetation becomes dead must also be considered as regards enemy visual observation from ground or air. Cut heather, however, remains effective in tone and colour against a heather background for some weeks.

Natural overhead cover afforded by existing trees or bushes should be used whenever available.

vi. *Tracks.*—The formation of new tracks must be kept to a minimum during the construction and occupation of any work. They show plainly in an air photograph. Concealment of an object is useless if the tracks which serve it are not dealt with. If a track is inevitable, it should be foreseen, and a dummy track made at the commencement of work leading past the work and continued to an apparently probable destination, such as a dummy position, an (unoccupied) building, a road or wood or pond. New tracks should, if possible, be taken through broken ground, trees, or woods, and should not be straight if this can be avoided. If sods have been cut for use as camouflage, the place from which they have been taken will generally be extremely conspicuous in air photographs, and unless great care is taken, the tracks made by men carrying the sods will give away the site of the work which is being concealed.

The danger of tracks may sometimes be avoided by siting works near existing roads or tracks, but in this connection, *see* vii., below.

vii. *Siting.*—When other factors are not of greater importance, it is desirable to avoid siting works which are likely to be apparent to air (or ground) observation close to roads, banks or other features which are marked on the map or easily distinguishable from the enemy's point of view. Siting works away from roads and other distinguishable features increases the enemy's difficulty in getting accurate locations to shoot at, particularly if he is unable to do much air photography.

viii. The degree of concealment obtained will depend on the intelligent use of the information given above, and the hints as regards specific works given in para. 6, below.

Whenever possible, faults in concealment should be corrected as a result of observation from our own aircraft.

5. Concealment from ground observation.—

i. Several of the points considered in relation to air observation apply also as regards ground observation.

ii. *Screening.*—The chief method of concealment is by siting works so that they are screened by existing features, such as hedges, banks, crops, woods, buildings or rising ground.

Considerations of concealment must not be allowed to interfere disproportionately with the fire effect of the garrison, but the employment of oblique fire, and acceptance of short but adequate fields of fire, will often permit works to be sited so that they are invisible to enemy ground observation prior to his attack, or only visible from distant points in his position.

iii. *Background.*—Concealment can be helped, apart from screening, by attention to background. Skylines, from the enemy's point of view, must be avoided, and occasionally it may be possible to confuse the enemy by making use of false crests. A dark background, broken up by small patches of light, affords the best concealment, and is the more effective the closer it is to the object to be concealed. Background is often as important as the immediate surroundings of a work in showing it up to ground observation.

iv. *Freshly dug earth.*—In parapets, this will always be conspicuous. This may be minimized for a short time, under certain conditions, by covering the newly made earth with grass or leaves, etc., but these change colour rapidly, and, unless the surrounding ground is very parched, the dead vegetation may be even more conspicuous than the plain earth. Sods, unless very carefully cut and applied, also become conspicuous, and in any case involve a great deal of labour and time. It must therefore be remembered that the digging of trenches (as opposed to small works, such as machine-gun emplacements) will always involve some loss of concealment of the position, though they afford concealment to the individual, which becomes more effective as the trenches become more extensive. These difficulties may be decreased by a free use of dummy trenches.

v. Whenever possible, proposed sites for work should be observed from the enemy's point of view before commencement of work, and this should be continued during its execution.

6. **Hints regarding concealment of various works.**—In addition to the more general considerations given in paras. 4 and 5, above, the following points should be observed :—

i. *Machine-gun emplacements.*—Concealment of machine-gun emplacements is of vital importance, and as these works are small and limited in number, a high measure of concealment can often be achieved, if natural or artificial overhead cover is available against air observation. The design of machine-gun section posts should resemble that of rifle and light automatic posts.

Whenever possible a site should be chosen which does not require a parapet raised above ground level. In these cases

the earth dug out of the emplacement should be removed to some distance or concealed under trees or bushes. A sandbag parapet is, in some surroundings, less conspicuous than freshly dug earth.

Special attention must be paid to tracks (*see* para. 4, vi., above).

Care must be taken that the lines of wire obstacles do not give away the position of the gun which commands them by pointing at it too obviously.

Similarity of construction of all machine-gun emplacements in an area may also lead to their detection in air photographs.

It should be borne in mind, however, that in mobile warfare isolated machine-gun emplacements are not an easy target for enemy artillery, even though they may have been detected by air observation. It follows, therefore, that the concealment of machine-gun emplacements from ground observation is more important than concealment from the air.

See sub-para. v. (Loopholes), below.

ii. *Observation posts.*—Except as regards wire obstacles, the same considerations apply as for machine-gun emplacements. Care must be taken about tracks used by men maintaining the telephone lines. Additional indications are given by the tracks made by linesmen patrolling the telephone line and by an approach trench cutting through the crest to give safe access, or to take away the spoil.

iii. *Obstacles.*—Wire entanglements are difficult to conceal, especially if made with wooden pickets. They should be made in irregular lines. Wire on heather or broken ground does not show up. Entanglements can sometimes be concealed by siting them along existing hedges or ditches. A wide belt of thin wire is less conspicuous than a narrow belt of thick wire.

As the tracks of erecting parties gives a clear plan of wire in suitable country for as long as 72 hours, existing tracks, or dried broken ground or heather which do not take tracks, should be utilized if possible.

Wire erected for some time is liable to be discovered by the long growth of vegetation under it, which shows dark in air photographs.

iv. *Trenches.*—These cannot be concealed from the air, except in thick trees. The top of the parapet should be as irregular as possible, as straight lines are conspicuous. Slopes of earth on the parapet should be gentle to avoid shadows (*see* para. 5, iv., above). In flat ground some kind of background must always be provided to prevent the heads of the defenders

showing up against the sky; this may often be done by having a parados rather higher than the parapet.

v. *Loopholes.*—The sides and mouths of loopholes often throw very black shadows. Unless unavoidable, loopholes should not point straight towards the enemy's position, but should be set obliquely in the parapet. The flanks of forward traverses are good positions.

Whenever possible the shadow cast by the mouth of a loophole should be broken up by covering it with a network of twigs or wire netting, etc.

No light must be allowed to show through loopholes, which must be provided with curtains if possible.

The outline of the parapet must not be broken by head-cover over loopholes.

18. *Observation*

1. General.—

i. If it is necessary to conceal the dispositions of the defence, it is equally necessary to make it difficult for the attacking troops to conceal themselves before and during their attack. This will naturally have been one of the main considerations in choosing the defensive positions and siting individual works, but much can be done by clearance to improve the observation of the defenders.

ii. Clearance must, however, be considered simultaneously with concealment, as unintelligent clearance may nullify efforts made to obtain concealment. In all cases the advantages of improvement of observation must be weighed against any loss of concealment involved. Weapons which remain concealed, even with a restricted field of fire, will be of more value than others, with a large field of fire, which lack concealment and are put out of action by the initial fire plan of the enemy. The valuable element of surprise in fire of the defence, particularly of localities in depth, may be lost through unwise clearance.

As a general principle, therefore, only the minimum clearance necessary to attain the object in view should be carried out.

iii. Clearance work should generally be undertaken early in the preparation of a defensive position, as once in contact with the enemy it is more difficult to continue than other work, owing partly to the difficulty of carrying it out efficiently by night.

2. Organization of work.—Clearance work is expensive in labour and tools and must be very carefully organized and

controlled if waste is to be avoided and rapidity of work achieved. Detailed preliminary reconnaissance from the position of observation must be made, and the objects to be cleared must be defined exactly. If work is carried out during successive nights, its value must be checked each day.

When possible the results of work should be observed from the enemy's point of view.

Before beginning, an estimate must be made of the amount of work that can be done in the time available with the men and tools which can be spared.

It can then be decided what work is to be done first. As a general rule, work should progress outwards, commencing close to the observation post or fire position.

3. Types of clearance.—

i. Work to improve observation falls under two heads:—

(*a*) *For observers.*—To assist them to observe enemy movement and the fire effect of the weapons of the defence.

(*b*) *For weapons and riflemen.*—To increase the area over which they can fire with effect.

ii. Work under i. (*a*), above, will usually entail the removal of obstacles which obscure the view from observation posts.

iii. (*a*) Work under i. (*b*), above, will usually mean clearing obstructions in an area, in order to improve the field of fire of small arms weapons.

(*b*) It will generally be unnecessary to clear away everything in front of fire positions. Hedges, lines of trees, patches of bush may often, if left standing, help to screen the fire trenches from the enemy's observers. They may often be of value as obstacles, especially if wire is added to them. Very often the partial clearance of the lower part of hedges will allow adequate vision without sacrifice of any concealment.

(*c*) Work on clearance should include leaving range marks, natural or artificial (if screened from the enemy), suitable for assisting the fire effect of the weapons concerned.

4. Detailed considerations.—

i. *Trees.*—Large trees give more cover to the enemy when cut down than when left standing. Their lower branches only should be cut away if they alone are causing the obstruction.

ii. *Bush.*—Areas covered with thick bushes are difficult to clear. They should be treated like a wood. Clearings or lanes should be made, and the edges of the part that is left should be filled with obstacles.

iii. *Buildings and walls.*—Small buildings and walls can be smashed down by a number of soldiers using a beam as a battering-ram. The debris must be levelled so as not to give cover to the enemy. Large buildings cannot be destroyed, and should be burnt so as to prevent enemy access to the upper floors for observation.

iv. *Crops.*—High crops, such as wheat, can seldom be cleared entirely, but by marching formed bodies of men through them, or by the use of cutting machines, if available, rides and indentations are quickly made. Clearing crops with sickles or scythes is a very slow process and requires skilled reapers.

19. *Communications*

1. i. The improvement of communications within a position can be of great assistance in the conduct of a defensive battle. Free movement across country is required, in order to save time and fatigue.

ii. Work is required in connection with :—

(*a*) The tasks of reserves and troops to whom counter-attack rôles have been allotted.
(*b*) The passage of individuals, orderlies, etc.
(*c*) Routine movements of troops, and of transport carrying rations, ammunition, etc.
(*d*) The system of evacuation of casualties.

iii. It is therefore not only necessary to provide single tracks (with gaps through hedges and means of crossing ditches) and routes for transport, but also to clear obstructions in definite belts of ground in order to facilitate the rapid movement of bodies of troops advancing on pre-arranged lines of counter-attack, both within and beyond the position.

2. Tracks for individuals do not entail much work ; but it is clearly necessary that time and labour on tracks for transport should be economized by concentrating initially on only one or two front to rear and one or two lateral routes in each convenient sector of the defence.

3. In development of communications attention must be constantly directed to the following points :—

i. Concealment from ground and, as far as possible, from air observation. For example, a track should follow the hedges round two sides of a field rather than go diagonally across in the open.
ii. Avoidance of likely shell traps.
iii. Care that selection of routes, and clearances involved, do not prejudice arrangements for concealment of other works.

iv. Avoidance of ground likely to become water-logged after heavy rain.

4. Routes should be marked while they are being made. This can be done in various ways, such as blazing trees, sticking in the ground at intervals cut branches of trees or sticks with sandbags on top. As soon as possible notice boards and arrows should be improvised to indicate direction, and also the type of transport permitted to use the track.

Marking of routes and tracks should as far as possible be recognizable by night.

5. Routes for night patrols, forward of the actual area of defence, should also be given recognizable marks, but care must be taken that these are not apparent to the enemy.

CHAPTER VII

OBSTACLES

20. *General considerations*

1. General.—Obstacles may be natural or artificial or a combination of both. The existence of natural obstacles may often be an important consideration in siting defences which, in such cases, will be placed so as to cover the obstacles by fire.

Every use should therefore be made of natural obstacles, such as swampy ground, woods, canals, rivers, hedges, ditches, as well as of existing fences. This is of particular importance in view of the development of armoured fighting vehicles against which artificial obstacles can seldom be provided.

It should be remembered that obstacles sunk in ditches cannot be easily destroyed by tanks.

2. Characteristics of a good obstacle.—These are :—

i. *Under direct fire.*—Unless obstacles are within sight and under direct fire of the defenders, they are useless, for they can be removed or surmounted by the enemy.

ii. *Concealed.*—Obstacles should be so placed that the enemy has difficulty in seeing them, cannot provide for dealing with them in his initial plan, and is therefore surprised by them. When possible artificial obstacles should be hidden in folds of the ground, behind and in hedges and ditches, below banks and in brushwood, woods and crops.

iii. *Not give away fire positions.*—Obstacles should not point directly at machine guns enfilading them ; nor should they be laid out in straight lines parallel with fire positions.

iv. *Irregular.*—A uniform thickness and depth of obstacles should be avoided. They should be laid out, as a general rule, in large zig-zags. Irregularity tends to break up an attack. Every opportunity should be taken of shepherding the enemy into pockets where the fire of the defence is most intense.

v. *Strong.*—They should (if artificial) be made of materials which cannot easily be destroyed by artillery fire.

vi. *Transparent.*—They should not be so thick as to give cover to the attacking troops.

vii. *Not obstruct the defence.*—In siting obstacles care must be taken that they do not interfere with pre-arranged plans for local counter-attacks and for employment of reserves. This is of particular importance in the case of obstacles connected with localities in depth. Well concealed gaps, particularly in forward obstacles, are necessary for the use of patrols. In protracted defence a carefully thought out system of gaps is necessary.

3. Classification.—

i. Obstacles may be broadly classified as protective or tactical, particularly with reference to wire obstacles.

ii. *Protective obstacles* are generally artificial and are required to prevent the defending troops being rushed by weight of numbers or surprise. Their siting is determined by, and will be close to, the works which they protect. They should be within the **zone of the defensive fire** of the machine guns of the defence.

Protective wire all round small posts will often be desirable in the early stages of development of a defensive system.

When possible, obstacles should be under enfilade fire from neighbouring localities.

iii. *Tactical obstacles* may be natural or artificial and are required to break up the enemy's attack formation, restrict his power of manœuvre and force his troops into convenient pockets under intense fire. They are of particular value in checking attacking armoured fighting vehicles or troops under the enfilade fire of suitably placed anti-tank or machine guns. If artificial, their position is determined in conjunction with the artillery and machine-gun fire plan. If natural, the weapons must be sited to suit the obstacle, as will generally be the case in anti-tank defence.

21. *Wire obstacles*

1. General.—The best artificial obstacles to stop infantry are those made of barbed wire.

The construction of wire obstacles is the duty of the troops holding the defences which they protect. If time is short it may only be possible to erect a single strand of wire, but every effort should be made to cover all defended localities by at least a single apron fence as early as possible.

Various types of wire entanglements are described below, but the double apron fence should be regarded as standard and all troops should be fully trained in its construction.

2. Double apron fence.—Plate 9 shows this entanglement. It consists of three horizontal wires fixed to the

pickets, sloping wires (called diagonals) leading from the top of upright pickets to the anchorage pickets, and three horizontal wires fixed on each side to the diagonals. These horizontal wires, together with the diagonals, are called the "front and rear aprons." The double apron fence is one of the best types of wire entanglement. It is difficult to cut or climb over. Two or three double apron fences, laid out so that the distance between them is always varying, form a very efficient obstacle which is not easily destroyed by artillery fire. Belts of such fences form a very good foundation for a wide obstacle; concertinas and loose wire can be thrown in between them to thicken the obstacle and make it more difficult to cross. Plate 10 shows how this is done.

3. Single apron fence.—If rapid work over long stretches is required, the rear apron of the double apron fence may be omitted. This entanglement is, however, much less effective and more easily destroyed than the double apron fence. The front apron should always be completed if possible.

4. Spider wire.—Consists of fences running in various directions with horizontal wires and without diagonals or aprons (*see* Plate 11).

Spider wire is very difficult to destroy by artillery fire, as there will nearly always be a few fences left undamaged. Not more than two or three fences should meet at one point.

It may be used to fill in the spaces behind and between double apron fences.

5. Knife rests.—Plate 12 shows two types of knife rests. They consist of two Xs made of wood or angle iron pickets joined together with spikes or a wire lashing.

These Xs are fixed near the ends of a round pole or distance piece, 10 to 15 ft. apart, and the wire is put on as shown in the plate. At least 18 in. of the central pole should project beyond the ends of the knife rest to make carrying easy.

Knife rests are used for blocking gaps in wire fences, and for closing roads and trenches.

6. Concertinas.—Plate 13 shows concertina wire obstacles. For these the barbed wire is first prepared as explained in Sec. **30**, and is carried up to the place where the obstacle is to be made. It can then be pulled out into long round fences and quickly fixed to pickets. The advantage of concertina entanglement is the rapidity with which it can be erected.

Its disadvantages are the considerable time and labour required to prepare the concertinas, the large carrying parties necessary and the fact that it is awkward to carry and easily gets tangled in the dark.

One row of concertinas is not very effective; there should be at least two rows 1 yd. apart.

7. French wire entanglement.—French wire is the name given to concertinas made of plain wire without barbs. These are provided ready made up, they are easy to carry and can be very quickly erected.

It is, therefore, useful for consolidating ground won in an attack.

It should be erected in two rows, 1 yd. apart.

The disadvantage of French wire is that it is easy to cross, and it is only used, therefore, until something better can be provided.

It can be improved by adding horizontal barbed wires, and by throwing loose barbed wire in between the rows.

22. *Road blocks*

1. General.—Road blocks may be designed either as absolute obstacles or as temporary obstructions. The object of the latter type is to check armoured fighting vehicles and to compel portions of the crew to leave the cover of their vehicle; such blocks must therefore be covered by the fire of the defenders. Suspicious marks which suggest the existence of mines and other dummies are of use in this connection.

The siting and type of block constructed will depend largely on the movement of our own troops.

2. Siting.—Sites should be selected in which it is difficult for crews of approaching vehicles to see the obstacle until they are close to it, or to turn round or move off the road once they have seen it. For example, defiles where the road passes between woods, deep ditches, thick hedges or buildings are obviously suitable, particularly if there is a bend in the road close on the enemy side of the obstacle.

Occasionally, if the road passes through long defiles, it may be possible to set traps by placing the obstacle well inside the defile and preparing a block at its entrance which can be rapidly put in position after the enemy vehicle has passed. This may take the form of a tree cut ready to fall but held by a single rope, or a concealed party ready to put out a French wire entanglement (*see* para 3, iv., below).

3. Construction.—

i. *Carts.*—Farm carts filled with stone or other heavy material form good road blocks. Unloaded carts, however, unless a great many are used, can be swept aside by armoured cars.

6. Page 44. *Delete* Section 23 and *substitute* :— 2/MAR/37

23. *Anti-tank mines and obstacles*

1. **Anti-tank mines.**—Against A.F.V. assault the anti-tank mine plays the same part that barbed wire does against infantry. The principles of its employment are very similar. Unless covered by the fire of the defenders, anti-tank mines are in most cases useless. In road blocks in particular the efficiency of the obstacle will depend largely on the skill with which the covering weapons are sited and the determination with which they are handled. Tanks, on discovering a mined road block, will usually try to work round it, destroy the defending troops and then remove the mines. To counter this, the latter should be placed so that they are encountered unexpectedly and where deviation is awkward. Close spacing (Plate 13A, Fig. 1) would normally be used in such cases.

Where wider gaps have to be closed, some form of open spacing (Plate 13A, Fig. 2) which is less expensive in mines will probably have to be used. It will not be fully tank-proof, but there should be enough mines to ensure that a tank attack cannot get through in any weight. And anti-tank weapons must be sited to deal with those tanks that penetrate the minefield. As with the wire obstacle, the deeper the belt of mines, the more difficult will be its passage or removal ; and the more effectively the minefield is concealed, the harder it will be for the attacker to plan his crossing. Mines may conveniently be laid in the wire obstacles of the defence, where not only will their detection be more difficult for the enemy but their location will to some extent be marked for friendly tanks.

In view of the importance of controlling and recording the laying of minefields these will in principle be placed by engineers. Occasions may arise, however, in mobile warfare when units liable to tank attack at very short notice will have to carry their own quota of the mines and lay them. Dummy minefields can be very rapidly laid and may be used to supplement live minefields.

2. **Natural tank obstacles.**—The creation of a tank-proof locality will usually involve a combination of anti-tank mines with natural and other obstacles. In selecting a defensive position, therefore, one of the first steps must be its reconnaissance from the anti-tank point of view. This is a task that will often have to be carried out at speed if the information is to be obtained in time to be of value to commanders who are making their dispositions. The following figures may be taken as proof against medium tanks :—

Vertical height over 3 ft.
Slope steeper than 45°.
Trench wider than 8 ft.
Water deeper than 3 ft. 6 ins.
Trees or stumps not less than 9 ins. in diameter (12 ins. with fir trees) and not more than 8 ft. apart.

The above figures require modification for different types of tank.

3. **Artificial tank obstacles.**—Although the anti-tank mine provides the quickest means for closing gaps not covered by natural obstacles, the gaps may be so many that artificial obstacles have to be made use of as well. Some examples of these are shown in Plates 13B and C.

a most effective obstacle against a savage enemy, especially round a perimeter camp.

Abatis have the disadvantage of being difficult to see through and masking the fire of the defenders, but this can be got over by placing the abatis so as to enable enfilade fire to be brought to bear along its outside edges.

2. **Inundations.**—These can be made by flooding low-lying ground, either by damming a stream or by making an opening in the bank of a canal. This should never be done in the absence of definite orders by the formation commander.

Even 6 in. of water on ground which has been broken up by shell-fire makes ground very difficult to pass over.

Loose wire thrown in the water makes it more difficult to pass. Fords of rivers may be obstructed in this way.

25. *Wiring drill—General*

1. In carrying out the drills the following points must be observed :—

i. Men must work in groups of two or three as laid down in the drills.
ii. Every man must do his own work and no one else's, even though one group may be working slower than the rest.
iii. Groups must work in the order given in the drill, a group which is working fast must not push past a slower group.
iv. Groups must regulate their speed so that they are 5 to 10 yds. apart. If the party bunches up there will be noise and casualties.
v. Men not working must lie down.
vi. The materials must be dumped near the head of the work, *i.e.* the end from which the party begins work, in a regular order so that every man knows where to find what he wants.
vii. The line along which the pickets of an obstacle are to be put in must be marked with tracing tape. If this is not done the working party is sure to lose its direction. The natural tendency is to come nearer and nearer to our own trenches.

Tape may also have to be used to mark the route from the place where the carrying parties dump the stores, to the site of the work.

2. Work may be from right to left or left to right. Men should always work facing the enemy when practicable.

ii. *Trees.*—Big trees felled across a road form a good obstacle. To fell a tree in a required direction, cut into it as far as the centre on the side on which it is required to fall. Then strain it in that direction by means of a rope, and finish off by a cut on the opposite side, about 4 in. higher up.

iii. *"V" trenches.*—A "V" trench cut in the road, 1 ft. 6 in. broad and 2 ft. deep, especially if covered with canvas or sacking on which road surface dust or chippings are sprinkled, forms a very effective trap against armoured cars moving at speed. This, however, requires time for preparation and is not suitable if the road is required shortly for use.

iv. *Wire.*—One or more belts of french wire concertinas form a useful obstacle against wheeled vehicles. Each concertina should be opened out and arranged in a U, with the open ends about a yard apart and facing the direction of probable approach of the enemy. The width of the road will determine the number of concertinas required in each belt. The wire must not be anchored or pegged down. The obstacle should be well covered by small arms fire to prevent removal by the crew. Amdt. 2 Mar., 1937

Barbed wire concertinas are not effective.

In mobile warfare time will seldom permit the construction of artificial tank obstacles other than minefields. They are of value in comparatively small gaps between tank-proof localities. Supply will seldom permit mining of large areas. In any case work of this nature will generally be done under engineer control.

24. *Miscellaneous obstacles*

1. Tree entanglements.—These may be formed by cutting trees or brushwood nearly through, about 3 ft. above the ground, bringing the upper parts down to the ground and interlacing and securing them by pickets.

Large trees thus treated form obstacles specially useful for blocking roads; the ends of thick branches should be pointed and weak places made thicker with separate branches cut and secured to pickets in the ground.

This is also a good method of making an obstacle along the edge of a wood to prevent the enemy from rushing trenches made behind the wood.

Vines or hops woven together with their tops picketed to the ground form very good entanglements.

In scrub or wooded countries an abatis of thorn bushes is a most effective obstacle against a savage enemy, especially round a perimeter camp.

Abatis have the disadvantage of being difficult to see through and masking the fire of the defenders, but this can be got over by placing the abatis so as to enable enfilade fire to be brought to bear along its outside edges.

2. Inundations.—These can be made by flooding low-lying ground, either by damming a stream or by making an opening in the bank of a canal. This should never be done in the absence of definite orders by the formation commander.

Even 6 in. of water on ground which has been broken up by shell-fire makes ground very difficult to pass over.

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v. Men not working must lie down.

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vii. The line along which the pickets of an obstacle are to be put in must be marked with tracing tape. If this is not done the working party is sure to lose its direction. The natural tendency is to come nearer and nearer to our own trenches.

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he wire must be pegged down if possible. SHOULD NOT be PEGGED DOWN.

v. *Gaps.*—It will often be desirable that blocks should not close the road completely. In these cases they should be made of two overlapping portions or placed where a house standing back from the general line allows a passage round of the required capacity.

23. *Tank obstacles*

In mobile warfare time will seldom permit the construction of artificial tank obstacles other than minefields. They are of value in comparatively small gaps between tank-proof localities. Supply will seldom permit mining of large areas. In any case work of this nature will generally be done under engineer control.

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v. Men not working must lie down.

vi. The materials must be dumped near the head of the work, *i.e.* the end from which the party begins work, in a regular order so that every man knows where to find what he wants.

vii. The line along which the pickets of an obstacle are to be put in must be marked with tracing tape. If this is not done the working party is sure to lose its direction. The natural tendency is to come nearer and nearer to our own trenches.

Tape may also have to be used to mark the route from the place where the carrying parties dump the stores, to the site of the work.

2. Work may be from right to left or left to right. Men should always work facing the enemy when practicable.

26. *Wiring drill—Method of fixing wire to pickets*

1. Before learning the drill for erecting double apron fences, every man must learn thoroughly how to put in pickets and how to make the fastenings by which the wire is attached to the pickets.

2. **Laying out pickets.**—Pickets are always laid out with their points pointing towards the enemy and at the exact place on the ground where they are to be put in.

3. **Putting in screw pickets.**—It is essential that all pickets should be screwed in so that their eyes are on the same side of the fence. If this is not done the men doing the wiring cannot make the knots quickly in the dark.

Screw pickets, both long and short, must be screwed in so that the eyes are parallel to the length of the entanglement, and that the cut end of the loop forming the eye faces or points towards the head of the task. The tops of some pickets are in the form of a loop, while those of others terminate in a straight point. In the latter, the cut end of the loop has been straightened out, and in applying the above rule it must be imagined that the end has been bent over.

4. **Putting in pickets.**—Angle iron pickets should be put in with the open end of the V facing the enemy (otherwise bullets may ricochet off the angles). In driving wooden or angle iron pickets, the tops of the pickets should be muffled. Muffling the head of mauls or sledge-hammers is never satisfactory.

5. **Short or anchorage pickets.**—Short screw pickets must be put in so that the pull of the fence comes in the direction of their length. Angle iron or wooden anchorage pickets should be put in so that they are at right-angles to direction of the pull.

6. **Fixing wires to screw pickets.—**

i. *To fix the wire in the top eye* of a long picket or in the loop of an anchorage picket—seize the running end of the wire, *i.e.* the wire on the side towards the drum, pull it tight and slip the wire up into the eye. If working from left to right it must be passed over the top of the picket Now continue the upward motion of the running end in a circle, bringing the wire down between the body of the eye and the point. The wire is now straight through the eye. Then take a turn round the picket below the eye, working clockwise. Plate 14 shows this knot being made when working from left to right.

ii. *To fix the wire in a lower eye :—*

(*a*) When working from left to right, the wire is pulled taut from the direction of the standing end, *i.e.* the end fixed to the previous picket. Slip the wire down into the eye. Pass the left hand under the wire and round behind the picket. Seize the running end and pull it in a loop round the picket, in the opposite direction to the clock. ~~Using the windlass stick~~, twist the loop round the runnir·g end of the wire. Plate 15 shows how this is done.

(*b*) When working from right to left, pull the wire tight with the left hand and slip it up into the eye from below. Put the right hand over the wire and behind the picket. Seize the running end and pull a loop round the picket above the eye, and windlass it on to the running end as before.

7. **Fixing wires to angle iron or wooden pickets.—**

i. *Horizontal wires.*—Pull the wire tight with the hand furthest from the head of the task. With the other hand pull a loop of the running end round the picket and windlass it to the standing part of the wire. Plate 16 shows how this is done when working from left to right.

ii. *Diagonal wires.*—Pull the standing end taut and pass the running end twice round the picket, so that when finished the standing and running ends cross one another.

They may then be windlassed together.

Plate 16 shows this being done when working from left to right.

8. **Fixing horizontal wires to diagonal wires.**—All horizontal wires must be fixed to alternate diagonal stays by windlassing. The diagonal wires must be left fairly slack when first put on.

9. **Starting and finishing of wires.**—All horizontal wires start and finish off at the anchorage pickets at the ends of the task. All diagonal wires start and finish off at the top of a long picket.

27. *Wiring drill—Double apron fence—General*

1. When in proximity to the enemy, all parties work on the nearer side of the fence. The drill given below, for erecting 50 yards of fence, is applicable to these conditions, and should be known by all officers and N.C.Os. :—

2. Although parties of one N.C.O. and ten men are laid down as standard wiring parties, wire can be erected rapidly

and silently by night by parties of any number from 6 to 15. The sequence of putting on the wires must be the same whatever the size of the party.

Men must always work in pairs, and on completion of one task, they must return to the head of the work where they can see, or will be told by an N.C.O., what the next task for them is.

3. In every case where two numbers are shown running out the wire, one man carries the drum and the other man makes the knots. On long tasks they will change round.

When full drums of 130 yds. of wire are used, the N.C.O. stands at the end of the fence and cuts the wires as they are finished off.

4. The man-loads of stores given in these drills are those for the numbers when carrying up the stores from the dumps to the head of each task (*i.e.* for a short distance), and when actually doing the drill. For long carries, with carrying parties, the loads are given in Appendix III.

Any spare men should be used to help the numbers who lay out and fix the diagonal wires, as these are always much slower than any one else.

5. It saves time and makes it unnecessary to cut the wire, if, before making a double apron fence, the wire is rewound into coils of 65 yds. each.

When laying out wire, the man carrying the coil should hold it so that the wire comes off from underneath.

If the wire catches, the coil will then be pulled downwards and not up into the man's face.

It is also less tiring for the hands.

6. Wire which is used for practising wiring soon gets kinked. It can be straightened by stretching and hammering out the kinks with wooden hammers.

28. *Wiring drill—Double apron fence—With screw pickets*

1. i. *Party*—

1 commander and 10 men.

ii. *Stores*—

	Man-loads
20 long screw pickets	5
40 short screw pickets	5
9 (65 yds.) coils barbed wire	9
2 (130 yds.) coils barbed wire (for diagonals)	4
Total ...	23

iii. *Tools*—

Windlassing sticks	10
Cutting pliers	1 pair

2. **1st Duty—Carrying stores.**—

Nos. 1 to 10, inclusive, make two journeys out.
N.C.O. directs.
Nos. 6, 7 and 10, make a third journey and bring up remaining stores.

3. **2nd Duty—Pickets.**—

1, 2, 3, 4, 5, long picket Nos.

1, 2, screw in long pickets, three paces apart (7 ft. 6 in.), along the tape; 3, 4 and 5 lay out pickets in position and then help 1 and 2 to screw them in.

6, 7, 8, 9, 10, short picket Nos.

6, 7, screw in short pickets opposite the intervals between long pickets, and 6 ft. from the fence on each side; 8, 9 and 10 lay out pickets in position and then help 6 and 7 to screw them in.

4. **3rd Duty—Wire.**—

Nos. 1, 2, 3 and 4, front diagonal wire (Nos. 1 and 3 run out wire, No. 2 fixes wire to long pickets and No. 4 to short pickets).
Nos. 5 and 6 bottom wire on front apron.
Nos. 7 and 8 centre wire on front apron.
Nos. 9 and 10 top wire on front apron.
Nos. 1 and 2 bottom wire on fence.
Nos. 3 and 4 second wire on fence.
Nos. 5 and 6 top wire on fence.
Nos. 7, 8, 9 and 10 rear diagonal wire (Nos. 7 and 9 run out wire, No. 8 fixes wire to long pickets and No. 10 to short).
Nos. 1 and 2 top wire on rear apron.
Nos. 3 and 4 centre wire on rear apron.
Nos. 5 and 6 bottom wire on rear apron.

29. *Wiring Drill—Double apron fence—With angle iron or wooden pickets*

1. i. *Party*—

1 commander and 10 men.

ii. *Stores*—

	Man-loads
20 long angle iron or wood pickets ...	5
40 short angle iron or wood pickets ...	5
9 (65 yds.) coils barbed wire	9
2 (130 yds.) coils barbed wire (for diagonals)	4
4 mauls or sledge-hammers	1
Total ...	24

iii. *Tools*—

Windlassing sticks	10
Cutting pliers	1 pair

2. 1st Duty—Carrying stores.—

Nos. 1 to 10, inclusive, make two journeys out. N.C.O. directs. No. 3 takes out mauls or hammers on his second journey.

Nos. 7 to 10, inclusive, make third journey and bring up remaining stores.

3. 2nd Duty—Pickets.—

Nos. 1 and 2 lay out all long pickets at 7 ft. 6 in. intervals along tape. N.C.O. paces out.

Nos. 3 and 4 drive in 8 long pickets.

Nos. 5 and 6 drive in 12 long pickets.

(NOTE.—Even Nos. hold pickets and odd Nos. drive them in.)

Nos. 7 and 8. No. 8 lays out 16 short pickets (1 at end of task and 15 along the front, and 6 ft. from fence and opposite intervals), and then assists No. 7 in driving them in.

Nos. 9 and 10. No. 10 lays out 24 short pickets (19 along rear and 6 ft. from fence, 1 at far end, and 4 along the front), and then assists No. 9 in driving them in.

4. 3rd Duty—Wire (same as with screw pickets, Sec. 28).

(NOTE.—Diagonal wires are windlassed at the pickets by the men who make fast the wire to the pickets.)

30. *Wiring drill—Barbed wire concertinas*

1. Making up barbed wire concertinas (Plate 13).—

i. Three men are required to make a concertina, and the tools and stores required are :—

(*a*) For each concertina—

1 coil of 130 yds. of barbed wire.
18 yds. of plain No. 12 wire, or 36 yds. of No. 14 wire.
About 50 ft. of thin binding wire, cut into 4-in. pieces.
2–5 ft. laths or bamboos.

(N.B.—Circumference = 13 ft. roughly, 2 turns each end = 52 ft.)

(*b*) For each party constructing concertinas—

String.
9 pickets, not less than 6 ft. long.
1 hammer or maul.
1 pair of cutting pliers.
1 frame as described below.
1 windlass stick.

ii. Draw a circle 4 ft. in diameter. Drive in 9 wooden or angle iron pickets at equal distances round this circle, leaving 5 ft. of the pickets above ground. The framework, made to fit over the heads of the pickets, as shown in Plate 13, is a convenience, but concertinas can be made without it.

iii. No. 1 now gets inside the ring of pickets, with his binding wire.

Nos. 2 and 3 run out the wires outside, as explained below.

iv. Take two complete turns round the circle of posts and at the foot of the posts with No. 12 wire, or four turns if No. 14 wire is used. Bind these wires together at each interval between the posts with binding wire. This forms a strong coil by which to pull out the concertina.

v. Fasten the end of the barbed wire to the end of the plain wire and take twenty-four turns round the posts in a spiral form, keeping time with No. 1 inside fixing the binding wire, as explained in sub-para vi., below, and finally finish off with plain wire as explained in sub-para. iv., above.

vi. With binding wire, starting at the bottom and working round and round, bind the wire to the turn below it at every second interval between the pickets. As there are an odd number of intervals the result will be that the wire will be tied first to the wire below it, then to the wire above it, and then to the wire below it, and so on, as shown in Plate 13.

vii. Take the framework off the top of the pickets. Slip a bamboo between the pickets and under the bottom of the

coil and place another over the top coil. No. 1 holds the top down while Nos. 2 and 3 work the coils up the pickets until they are closed up to a depth of a few inches. The laths or bamboos are then tied with string as shown in Plate 13, and the coil is carried away. A second concertina can then be begun.

2. Carrying and opening out concertinas.—Concertinas when made up as described above can be carried by one or two men as shown in Plate 13.

To open out a concertina, two men are required. The bamboos are removed. Each man takes hold of the plain wire rings with both hands, and the concertina is extended to 18 ft.

Concertinas should be pegged to the ground with U-shaped pieces of iron. They can be stiffened by being dropped over pickets put in 3 yds. apart, and by being windlassed to a wire run along the heads of these pickets.

3. Drill for erecting a double belt of concertinas.—

i. The following drill may be used for erecting concertina obstacles:—

(*a*) *Party*—

1 commander and 7 men.

(*b*) *Stores*—

	Man-loads
8 bundles of 4 long pickets	8
1 bundle of 2 long and 4 short pickets (mixed bundle)	1
16 concertinas	16
2 (130 yds.) coils barbed wire ...	2
Total ...	27

ii. *Time.*—By day 20 minutes, by night 30–35 minutes.

iii. *Stores.*—Commander leads out party taking with him the "Mixed bundle." Nos. 1, 2, 3 and 4 each take out 1 bundle of long pickets. Nos. 5, 6 and 7 take out 8 concertinas and 1 bundle of barbed wire (3 journeys).

iv. *Pickets.*—Commander takes a half of his mixed bundle, places one anchor picket at the beginning of the task and the first 2 yds. from it, he then paces out for the remaining long pickets (9 ft. intervals), and places one anchor picket at the far end of the task.

Nos. 1, 2, 3 and 4 lay out their pickets, in succession, at

the place indicated by the commander, and then screw them in. No. 1, in addition, screws in the anchor and long picket laid out by the commander at the commencement of the task, and No. 4 screws in the anchor picket at the far end of the task. Nos. 5, 6 and 7, when they have completed their third trip for stores, open out each concertina and place it in front of the pickets at intervals, along the fence, ready for placing in position.

v. *Wire.*—Nos. 1 and 2 place the ends of the concertinas over the pickets. (No. 2 places only the bottom of his end of the concertina over his picket.) Nos. 3 and 4 (No. 4 working on enemy side) then lift the centre of each of the concertinas, in turn, over the centre pickets. They are responsible for windlassing the ends of the concertinas together. Nos. 5, 6 and 7. No. 5 runs out the bundle of barbed wire, No. 6 fixes it to the pickets, commencing and finishing at the anchor pickets. No. 7 windlasses this horizontal wire to the top of the concertinas, in three places between each pair of pickets.

vi. To complete the second belt the above drill is repeated, with the exception that the commander does not return to the dump. The pickets of the second belt should be 7 ft. in rear of the pickets of the first belt, the anchor picket being in rear of the first long picket of the first belt.

vii. Should it be necessary to strengthen the above double belt, an extra horizontal wire is placed along the front of each belt and loose wire is thrown in between the two belts, as follows:—

Nos. 1 and 2 run out and secure horizontal wire on front belt.

Nos. 3 and 4 run out and secure horizontal wire on rear belt.

Nos. 5, 6 and 7 throw in the loose wire between the belts.

Extra stores and time for strengthening the normal double belt of concertina fence must be added to that given in sub-para. i., above.

31. *Wiring drill—Miscellaneous*

1. French wire.—French wire is erected in exactly the same way as the barbed wire concertinas described in Sec. **30.**

2. Loose wire.—

i. Loose wire is used, as already described, for throwing between belts of concertinas or double apron fences or French wire, to make the obstacle more effective.

ii. It is prepared for throwing as follows :—

Drive in two 6-ft. pickets, 3 ft. apart, and at right-angles to these, and at 1 ft. 6 in. apart, drive in two others. Wind a coil of barbed wire round the four pickets as though making a small concertina. Press the turns together tightly and tie the bundle so made in four places with string. It is then ready for carrying on the shoulder.

Two men can make one of these spirals in 5 minutes.

To use the loose wire so prepared, cut the string bindings, carry the spiral on the left arm and walk along, throwing two or three coils at a time into the entanglement with the right hand or windlass stick. One spiral supplies enough loose wire for a bay, 2 yds. wide and 25 yds. long. A man should be able to throw it almost as fast as he can walk.

iii. Another way of throwing loose wire is as follows :—

Uncoil 50 yds. of barbed wire on the ground, cut it, pick it up with a long forked stick, twisting it to and fro, and throw it into the entanglement. Press it well down and secure it to the wires of the entanglement by windlassing.

32. *Preparations for rapid night wiring*

1. The following preparations must be made if wiring is to be carried out rapidly and quickly at night without confusion and casualties :—

i. Parties should be told off and practised in their work.

ii. The stores should be collected in dumps in convenient places close to the work.

iii. The wire must be prepared as follows : The pieces of thin iron at the ends of the drums must be broken off. The binding wire with which the end of the barbed wire is tied must be removed, and the end must be tied with a piece of white tape or sandbag, so that it can easily be found in the dark.

iv. The wire binding on bundles of pickets must be replaced by string which is easy to cut. No binding which has to be undone in the dark should be made of wire.

v. Mauls or hammers should not be padded as this is never satisfactory. The top of pickets may, however, be padded.

vi. All stores should be prepared in man-loads.

vii. Tracing tapes should be laid from the dumps to the site of work and along the line of the fences.

CHAPTER VIII

FACTORS GOVERNING DESIGN OF PROTECTIVE WORKS

33. *General principles*

The principles governing design of protective works should be understood so that normal designs can be altered or adapted to suit local conditions, without loss of efficiency.

The three main principles are :—

i. The work must permit the effective use of the defenders' weapons.

ii. The work must provide protection from the enemy's weapons.

iii. The work must be inconspicuous.

34. *Use of weapons—Governing dimensions*

1. **The rifle.**—In the positions stated a man can fire his rifle over the following heights :—

(1)	Fires over (2)	Distance needed behind (3)	Remarks (4)
i. Lying ...	9 to 12 in.	5 ft.	Man not covered from view, cannot move about. Badly exposed to shrapnel fire.
ii. Kneeling or sitting ...	30 in.	3 ft.	Man cannot sit under cover, and can only move with difficulty without exposure.
iii. Standing...	4 ft. 6 in.	2 ft.	Man can sit and crawl without exposure, extra width needed for easy movement.

2. **Other weapons.**—The maximum heights over which other weapons can fire is shown below :—

i. Light automatic.	As for rifle.
ii. Machine-gun or tripod mounting. (Firer in sitting position.)	24 in.
iii. 18-pr. field gun.	30 in.
iv. 4·5-in. howitzer.	30 in.

35. *Protection required against different types of fire*

1. **The rifle bullet.**—The table below shows the thickness of various materials which a bullet can penetrate. It also shows the thickness which should be provided to give adequate protection.

Prolonged concentrated fire (for example, from a machine gun) will penetrate these thicknesses. Though this effect is not likely to occur often, it may be necessary, in special cases, to provide extra thickness for protection.

Small-arm fire at effective ranges has a flat trajectory and cannot search steeply behind a protective parapet.

Material (1)	Penetration in inches (2)	Minimum thickness in inches to be provided (3)	Remarks (4)
Steel plate ...	¾	1	—
Shingle or broken stone ...	6	9	If pieces do not measure more than 1 in. placed between boards.
Coal (hard) ...	9	13	Between boards.
Coal (kitchen) ...	15	23	Between boards.
Brickwork in lime mortar ...	14	21	—
Chalk	15	22	—
Sand, confined between boards or in sandbags	18	27	—
Sand, loose ...	30	45	—
Earth, free from stones, unrammed ...	40	60	Ramming earth reduces its resisting power.
Sawn timber, hard wood, *e.g.* oak	38	57	In round timber the penetration is much less than in scantling, owing to the deflection of the bullet, but care must be taken to fill the interstices.
Soft wood, *e.g.* fir	56	84	
Freshly-cut timber logs 12-in. diam. and over	24	36	—
Poles 4½ to 8 in. in diameter ...	38	57	—
Clay	60	90	Varies greatly. This is maximum for greasy clay.
Dry turf or peat	80	120	—
Snow	[rammed snow]	60	Varies greatly. Soft snow has little power of resistance.

2. **Shrapnel.**—The bullets come down at a steep angle and have very little power of penetration.

A brick wall 9 in. thick, a bank of earth 18 in. thick, or the roof or floor of a good building, will be sufficient to stop them.

3. **H.E. shells with instantaneous fuze.**—These shells burst directly they touch the ground. The effect is mainly lateral, and the splinters have a flat trajectory and sometimes fly for distances of 200 or 300 yds., but they have very small penetrative power and are stopped by a 9-in. wall, or a bank of earth 2 ft. thick.

4. **H.E. shells with non-instantaneous fuzes.**—These burst after penetrating for some little distance, and are of more value against material than against personnel. The splinters from these shells have less penetrative power than those mentioned above, but the force of the explosive tends to shatter surrounding material. Good protection, against the effect of splinters from shells, can be afforded by narrow slit trenches (Sec. **39**).

Little can be done in hasty defences to protect against **direct** hits of these shells, as the amount of material needed for safety is too great; in deliberate defences, however, dug-outs can be made deep enough to afford protection.

5. The effect of direct hits by these shells is limited by :—

i. Avoiding long, straight lengths of trench or work.
ii. Providing traverses.
iii. Holding up the sides of trenches by revetment.

CHAPTER IX

PROTECTIVE WORKS

36. *Machine-gun emplacements*

1. **General.**—In mobile warfare there will seldom be time or material for elaborate emplacements, and guns will have to rely for protection purely on concealment and on hasty emplacements. The type of the emplacements will depend upon the time, labour and tools available, the siting and the nature of the soil. In constructing obstacles it is necessary to consider the arcs of fire and fixed lines of machine guns.

The constructor of concrete emplacements is the responsibility of the engineers. The emplacements will as soon as possible be connected by trenches to the section commander who occupies a suitable position from which he can control both guns.

The gun must have a firm and steady base for the feet of its tripod and it must be able to fire over the whole arc required. Machine-gun emplacements must give bullet-proof protection from every direction from which fire may be expected.

The minimum dimensions of an emplacement for a gun mounted in the normal position are shown in Plate 17. The front to rear dimensions may be reduced by mounting the gun in the highest position (*see* Plate 18) and embedding the front legs in the parapet.

2. **Hasty emplacements.—**

i. A type of emplacement which can be easily and quickly made is shown in Plates 18 and 19.

Subject to obtaining the requisite command, the tripod leg should be cut well into the bank or parapet so that overhead cover, if added, will not break the continuity of the bank or parapet, thus giving an appearance as identical as possible with a rifle trench, when viewed from the air.

The platform should be revetted as early as possible. When the ground is soft or unsuitable, a " T " base should be placed in position on the platform.

ii. Hasty emplacements made in shell holes should be as simple as possible in order to facilitate concealment.

Plate 19 shows a type of this form of emplacement. Drainage in this case is best effected by carrying the water off to a deeper shell hole, but the drain must be concealed.

3. **Development of hasty emplacements.—**

i. When time permits a hasty emplacement may be developed as shown on Plate 20 for open ground, or as Plate 19, when constructed behind banks or in shell holes.

Cover for the personnel not actually serving the gun should be provided in the form of shell slits (Plate 30).

The development of two machine-gun emplacements into a machine-gun post is shown in Plate 21.

ii. When further time is available, and subject to concealment from ground observers, a light roof can be built over the emplacement to give cover from weather.

The roof should, if possible, consist of two sheets of corrugated iron or boarding, supported on 3-in. by 3-in. rafters, about 7 ft. long, resting on light poles, 4-in. by 4-in. scantling about 4 ft. long.

Only enough earth should be thrown on the roof to hide it. If more than a few inches of earth are used, the emplacement will collapse when a shell bursts near it, the occupants will be buried and the gun put out of action.

iii. The inside of the emplacement should be revetted (Chapter XI) and an opening left for the gun to fire through.

4. **Wall emplacements.—**

i. An emplacement can readily be made behind a garden wall, or in a house, by knocking a hole (Sec. **52**) in the wall and building up a platform for the gun behind it.

Care should be taken that the hole is wide enough for the gun to cover the necessary arc of fire.

The platform should be firm and not smaller than 4 ft. in length and 4 ft. in width.

It can be made of old bricks or boxes filled with earth or improvised material.

A machine gun sited behind an inner wall and firing through a hole in an outer wall is extremely hard to locate.

ii. If a pivot platform is used, the gun when placed upon it, pivots about its muzzle. This avoids the necessity of a wide loophole and so facilitates concealment.

37. *Fire trenches*

1. **General.**—Plate 22, Fig. 3, shows the section of a fully developed, normal fire trench. The following paragraphs will explain its component parts and sequence of digging tasks and revetment. Plate 23 shows the section of a weapon pit, which is the same as Task I, Plate 22, Fig. 2.

2. Parapet.—

i. This should be at least 5 ft. thick at the top for protection against enemy rifle and machine-gun fire.

ii. The closer the top of the parapet is to ground level the easier it is to conceal, but a minimum height of 18 in. is generally necessary to give the firer sufficient command. If the parapet is lower than this, it may also be difficult to dispose of the earth dug out of the trench.

iii. The top of the parapet should not be flat and even, but should be as irregular as possible. The parapet should slope gently towards the front.

3. Parados.—

i. This serves two purposes :—

(*a*) To protect the firer from splinters of shells bursting behind the trench, and also from reverse fire.

(*b*) To form a background so that the heads of the firers may not show up against the sky or light coloured ground which may exist behind the trench.

ii. The parados should, if possible, be bullet-proof; but this is not usually as important as its height, which should be greater than that of the parapet, in order that the defenders' heads shall not show up against the sky or a light background.

4. Berm.—

i. The berm is the space between the foot of the parapet or parados and the edge of the trench. It should never be less than 12 in. wide.

ii. It is essential in order to prevent :—

(*a*) the excavated earth on the parapet or parados falling into the trench;

(*b*) the weight of the parapet or parados breaking down the edge of the trench.

5. Firestep.—

i. The firestep should be at least 2 ft. wide, must be firm, and when possible should be revetted. The depth of the firestep below the top of the parapet should normally be 4 ft. 6 in.

ii. On occupying a fire trench every man should, at once, test the height of the parapet and make sure that he can fire over it.

6. Cross-section—General dimensions.—

i. The sides of the trench are dug as steep as possible—for protection, but not steeper than 4/1 so that they may stand for a time without being revetted.

ii. The fire trench must be wide enough to fire from efficiently, and, later, widened further so as to permit walking behind the firing.

The varying conditions, such as enemy armament, nature of ground, in different theatres of war will influence the question of width.

iii. When time permits there should be a passage 2 ft. wide behind, and deeper than the firestep.

7. Sequence of digging tasks and revetment of fire trench.—

i. Plate 22, Fig. 2, shows the three stages in digging a " fully developed " fire trench.

(*a*) In the first instance Task I will be excavated. All the earth from this task must be thrown on the parapet, ~~which even so will not be 5 ft. thick~~.

(*b*) Then if time is available, this trench, 3 ft. 6 in. wide and 3 ft. deep, will be widened by digging out Task II. **It should not be deepened until it has been widened.**

The earth from this task must be thrown on the parapet until it is bullet-proof, the rest being thrown on the parados.

(*c*) Finally, if further time is available, the passage way as shown in Task III will be excavated, the earth being thrown on the parados.

(*d*) As soon as possible the firestep should be revetted. If further time is available the remainder of the trench will be revetted (*see* Chapter XI).

8. Traverses and trace of fire trench.—

i. *General.*—This paragraph applies mainly to a fully developed trench system as used in protracted defence. In mobile warfare, however, the possibilities of further development must, from the earliest stages, receive consideration.

If this is not done, the work carried out during the first few days of occupation of a defensive position may be found useless and further development of field defences becomes necessary.

ii. *Traverses* (Plate 25, Fig. 1).—Traverses are buttresses of earth left projecting backwards from the forward edge of the

trace of the trench, and so splitting up the forward face into short lengths (fire bays).

They serve two purposes :—

(*a*) To give protection against enfilade fire, for which purpose their top should be higher than the top of the parapet, but no higher than the parados, or they will show exactly where the fire bays are.

(*b*) To localize the effect of a bomb or shell bursting in the trench.

For these purposes traverses should be about 15 ft. thick.

In a fully developed trench the depth of a traverse from front to rear should be about 12 ft. in order to allow for the necessary overlap of the trench when fully developed.

The passage round traverses should be wide enough to allow stretchers to be carried through them.

In a section post or defended locality where all-round defence is necessary, the passage behind traverses may be provided with firesteps.

iii. *Adding a traverse to a trench.*—It is sometimes necessary to add a traverse to an existing trench, as shown in Plate 24.

The method of doing this is as follows :—

(*a*) First dig the additional communication trench required to pass round a traverse 15 ft. wide with an overlap of 5 ft. behind the back of the existing trench.

(*b*) When this trench is ready, properly drained, and trench-boarded, build two revetment walls across the old trench up to ground level. Plate 34 shows a picket and either brushwood or sheet revetment, in which the two sets of pickets are anchored to each other by wires at the bottom, middle and top.

(*c*) After the revetments are ready, or as they are being built, fill in the spaces between the revetments with the earth which came out of the trench.

(*d*) Make up the parados and the top of the traverse to the proper shape.

iv. *Fire bays* (Plate 25, Fig. 1).—These are the parts of a trench between traverses. Each firer is allowed roughly 6 ft. of fire bay. Fire bays should not, as a rule, exceed 30 ft. in length, otherwise the traverses will not afford sufficient protection from enfilade fire.

v. *Trace of fire trenches :—*

(*a*) *General.*—The trace of a trench is its plan on the ground. In mobile warfare it will initially take the form of short lengths of trench (*i.e.* weapon pits, Plate 23) which will later be connected up into a series of fire bays with traverses in between (Plate 37). As these fire bays have to be fitted to the ground, the trace will vary to suit different conditions and undulations.

The trace should not contain long, straight lengths of open trench which may be exposed to enfilade fire (*see* Fire bays, above).

Besides being irregular in itself, the general line of the trace must be laid in bold curves, so as to increase the enemy's difficulty in organizing bombardment. This will also assist the defenders in using enfilade or oblique fire.

There are various types of trace of which the most commonly used are described below.

(*b*) *Square.*—The square trace consists of a series of fire bays, separated by traverses at right-angles to the fire bays (Plate 25, Fig. 1).

This type gives the best protection, for all the angles are well closed in, but it is slightly extravagant in time and labour.

(*c*) *Bastion.*—The bastion trace (Plate 25, Fig. 2) is similar to the square trace, but the sides of the traverse are set at about 135 degrees with the fire bays. This type gives good protection, but is more open at the angles, does not involve quite so much work over a given length of line, and is easier for traffic and fire control.

As any portion of a trench dug with this trace can be prepared as a fire position to give fire in any direction it is particularly useful for communication trenches.

(*d*) *Zig-zag.*—The "zig-zag" trace (Plate 26, Fig. 1) consists of a number of fire bays laid out in a series of zig-zags, of which no angle can be greater than 135 degrees, nor less than 90 degrees.

This trace is simple to lay out, quickly constructed, but depends for protection on its irregularity of line, for there are no traverses. In warfare against a well armed enemy it is not recommended.

(*e*) *Dog leg.*—The dog leg trace (Plate 27, Figs. 1 and 2) is useful for a continuous line across a valley with deep sides.

(*f*) *Alternatives.*—Some alternative traces based on

combinations of the above are shown on Plate 26, Fig. 2, and Plate 28.

(*g*) *Common type.*—A common type which has been much used is a combination of the "square" and "bastion" trace.

(*h*) By using T-heads and D-heads advantage can be taken of accidents of ground forward of the main trench.

38. *Communication trenches*

1. **Object.**—The objects of communication trenches are to provide :—

i. Concealment.
ii. Protection.

It is essential, however, that all communication trenches be prepared so that in places fire can be delivered from them in any direction in the event of penetration.

Communication trenches may connect fire trenches in a defended locality, or one locality with another, or may extend from different parts of forward area to the rear of the position.

2. **Dimensions.**—To start with, communication trenches will be dug 3 ft. deep, 3 ft. 6 in. wide at the top and 2 ft. wide at the bottom. Then as time permits they will be deepened to the full depth as shown in Plate 29, Fig. 2, which allows men using them to walk upright without exposure.

3. **Development.**—

i. The development of the trench will be in two forms :—

(*a*) Deepening and widening.
(*b*) Lengthening.

ii. *Details of construction.*—The following points should be borne in mind during the construction of communication trenches :—

(*a*) For protection from enfilade fire and shrapnel the trace must be irregular, *i.e.* "winding," as shown in Plate 29, Fig. 1.

The minimum curve in winding communication trenches so that a stretcher can be carried round it, is 16 ft. radius. The portion of the trench between two bends is called a "leg."

(*b*) There should be parapets on both sides of the trench, but in the first instance the parapet on the exposed side is the more important.

(*c*) The length of a "leg" should not generally be more than 10 yds., to avoid exposing a long length to fire and to limit the effect of shell bursts.

(*d*) A berm 1 ft. 6 in. wide must be left between the edge of the trench and the foot of the parapet on each side.

When digging out the first task a berm about 3 ft. wide should be left so that the earth from the second task can be thrown on the inside of the half-formed parapets. It is difficult to throw earth over the top of the parapet from the bottom of the trench.

(*e*) The depth of the completed trench, from the top of the parapet to the trench-board, should be 7 ft. to allow men to walk along it without exposure.

(*f*) The width at the bottom should be 3 ft. It should not be more than this, as then the trench would be wider at the top, and protection diminished. If less than 3 ft. wide at the bottom, passing will be difficult.

(*g*) The slope of the sides should be 4/1 or 3/1 according to the soil.

(*h*) Passing places, and in a long trench occasional sidings, should be provided for, to facilitate passage of large parties of men.

When time permits (usually only in protracted defence) there should be different communication trenches for "up" and "down" traffic.

(*i*) Ramps or steps should be provided at intervals so that men can get out of the trench if desired.

(*j*) Notice boards should be erected at all important junctions to show where the trenches lead.

(*k*) A communication trench which enters a fire trench from the rear should do so if possible at the back of a traverse, or some other position where it will not be exposed to direct fire.

(*l*) The importance of drainage, as stated in Sec. **40**, applies with equal force to communication trenches.

39. *Shell slits*

1. Slit trenches, shown in Plate 30, are useful to give protection from shelling and aeroplane bombs.

2. They should be about 3 ft. wide at the top and 4 ft. deep. They are usually dug at right-angles to communication trenches and on each side of them. The slits should be made zig-zag in plan and each should be long enough to take 10 or 12 men, or about 25 to 30 ft. in length.

3. They should be shored or strutted (Plate 30) as early as possible to prevent collapse, and when time is available steps, for egress, should be provided at the end away from the communication trenches.

4. They should be drained.

40. *Drainage of trenches*

1. Drainage of trenches and fire positions is of the greatest importance. If neglected, trenches collapse, and disappear in bad weather.

Drains should be put at the lowest point of each fold in the ground, and the bottom of the trench graded so as to fall towards them without any intermediate depressions.

Excavation of drains should be done up hill and the bottom of the trench graded before work ceases each day, so that pockets, formed by unfinished tasks, are not left to collect water.

2. **Sumps or soakage pits** (Plate 31).—These should not be relied on unless natural drainage is impossible. Unless the sump reaches a permeable stratum, it must be pumped or baled out. The main sump should be provided clear of the actual trenches. Until trench-boards are issued use should be made of any suitable material available. Sump pits must be revetted above water-level with a skeleton revetment, kept in position by bracing across the sump. Below water-level, the pits must be revetted with brushwood, XPM, or corrugated iron. When constructing a trench system, until the main sumps can be provided, it will be necessary to provide small sump pits in the trench itself.

3. In occupied trenches, the mud which is churned up by traffic will make drainage impossible unless trench-boards are laid with a clear space for water to flow beneath them.

Trench-boards should be laid as soon after digging the trench as possible, for, after a heavy shower, traffic will quickly convert the bottom of the trench into a slough.

4. The maintenance of a drainage system must be carried out by the troops in occupation.

41. *Miscellaneous details of trenches*

1. **Latrines** are required in trenches and should be constructed as early as possible. They are arranged for in small trenches dug off communication trenches.

2. **Recesses.**—Parapets should on no account be under-cut to make recesses for ammunition, etc., otherwise they may collapse under shell fire.

3. **Name-boards.**—When time permits name and direction boards should be erected, especially in connection with communication trenches and junctions. These can be very rough pieces of board in the first instance.

4. **Exits.**—Fire trenches should, when labour is available, be provided with numerous exits towards the front and rear. These exits are required for patrols, working parties, and for counter-attack parties to move out.

5. **Bridge traverses.**—Long and very exposed lengths of trench can be protected and hidden from the direct view of the enemy by the use of bridge traverses. Plate 32 shows a bridge traverse. They must not be higher than any other part of the parapet and their weight should be taken on wooden uprights let into the side of the trench.

If the traverse is built on the side of the trench, without its weight being supported independently, the side of the trench will collapse.

6. **Defence against bombing.**—Special arrangements must be made to prevent the enemy's bombers making their way down communication trenches.

Where a communication trench projects from a fire trench towards the front, there should be a straight portion for the first 45 yards, and arrangements must be made for rifles or a light automatic gun to fire down this "straight" (Plate 33).

The straight piece of the trench must be wired on both sides, and some obstacle, such as a knife rest, which can be pulled down as required, must be provided and placed in a recess at the side of the trench or on the berm.

42. *Breastworks*

1. Breastworks (Plate 34) are made when it is impossible to obtain cover by digging trenches; for instance, in rocky country where there is little or no earth, or in marshy country where the water lies on or close to the surface.

2. The trace and profile of breastworks follow the same general rules as for trenches, but the following special points must be borne in mind:—

i. A breastwork may be constructed by putting up two revetments of gabions or hurdles—or, if using sandbags, by building two sandbag walls—10 ft. apart (from outside to outside at ground-level); filling in between with earth; building up a bursting course of harder material in front; and finally making a very gentle slope to the front. Details of anchorages are laid down in Plate 35.

ii. Breastworks constructed of sandbags are much more vulnerable to artillery fire than breastworks made of two revetments with earth-filling in between.

Sandbags are used when silent work is required. A sandbag breastwork must be built in the same manner and with the same precautions as laid down for sandbag revetments (Sec. **46**, 3).

iii. Traverses must be provided as in fire trenches, and there must be a firestep, to allow of every man using his rifle over the parapet.

iv. The parapet must be at least 5 ft. thick at the top, the exterior slope between 1/2 and 1/3, and the borrow pit, from which the earth for the parapet is obtained, must be traced so that a berm of 3 ft. is left between the toe of the exterior slope and the edge of the pit (Plate 34).

v. The necessary amount of cover for free movement along the line (6 ft. 2 in. as a minimum) can be obtained, either by building up the parapet to this height, in which case a raised firing step will be required, or by having the firing step at ground-level and by digging a narrow, shallow trench immediately behind it, and round the traverses.

vi. A parados must be constructed to protect the garrison from the backblast of high-explosive shells. This parados should be bullet-proof (4 ft. thick) at its top, and strongly revetted on both faces. It should be as high as or slightly higher than the parapet.

vii. The space between the breastwork and the parados should if possible be trench-boarded, and drainage must be provided.

A path paved with bricks or trench-boarded just behind the parados is a great convenience. It should communicate with the fire bays by openings through the parados behind at least every other traverse.

viii. If shelters for men are required these must on no account be constructed under the parapet, but behind the parados. Each shelter so constructed will require a parados of its own.

43. *Light shelters*

1. Small shelters (Plate 36) to give protection against shrapnel and splinters can be constructed without a great expenditure of labour and materials. This protection is given by 12 in. to 2 ft. 6 in. of earth. It is unnecessary to have more than this amount as an earth cover is not shell-proof unless some 20 to 30 feet is used, and any thickness much less than this and more than 2 ft. 6 in. only increases the explosive force of the shell which may penetrate it.

In order to cause a shell to explode before it can penetrate the earth cover, a "bursting course" consisting of a layer of 9 in. of hard non-rigid material (such as broken bricks, stones, etc.) is laid on top of the earth covering. A bursting course is always a useful addition to shrapnel-proof cover, but the depth of the whole roof covering should not exceed 2 ft. 6 in.

2. The earth cover with its bursting course may be supported on a framework of wood (described in para. 4 below).

The earth cover may also be carried on corrugated iron sheets, hurdles, planks, etc., laid across a revetted trench, but fire and communication trenches should not be treated in this way as they quickly become blocked under shell fire. If such overhead protection is required recesses should be dug off the fire and communication trenches or special trenches leading off the latter.

3. The following covers have been used with success against shrapnel :—

i. 12 in. to 1 ft. 9 in. of earth with bursting course, 9 in. thick, of broken brick supported on C.I. sheets, hurdles or planks, resting on a wooden frame.

ii. 2½ feet of earth supported on a layer of 8-in. logs resting on a wooden frame.

4. **General construction points.**—Shelters intended to be shrapnel-proof are generally made on the "cut and cover" principle; an excavation being made in which the shelter is built and then covered up. No roof, whatever its resistance to penetration, is of any value unless it is supported on a properly designed structure.

This should be in the form of a box braced in every direction, as the dug-out must be strong enough to stand the concussion of shells bursting a few yards away, even though the roof is only splinter-proof.

The essentials are :—

i. Strong sides and roof.

ii. Sides must be prevented from collapsing inwards by being strutted apart top and bottom.

iii. The whole box must be prevented from distortion by diagonal bracing on the sides and end.

iv. Sills or bearing plates must be placed under the uprights supporting the roof to prevent them sinking into the ground.

v. The shelter must be rendered weatherproof by including in the roof a layer of corrugated iron or similar material, graded to throw off water. When corrugated iron is used any nails should be driven through the ridges and not through the valleys of the corrugated iron.

In addition, water must be prevented from draining into the dug-out.

Where the dug-out is made off a trench this can best be effected by making the floor of the dug-out about a ~~foot~~ 2" above the bottom of the trench.

5. **Hints on the use of timber for framework of shelters.**—The following points should be observed:—

i. Beams must be laid on edge to obtain the full strength.

ii. In covering a given area beams should be placed across the shortest span.

iii. If there are any large knots in the beams they should be placed uppermost and not on the underside of the beam.

iv. Heavy weights must not be taken by nails or on an unsuitable support such as sandbags.

v. The best upright is the natural pit prop. When round timber is not used, uprights should be as nearly square as possible in section and one side should never be less than five-eighths of the other.

vi. Uprights must rest on a footing or ground sill, usually a thick plank, to distribute the pressure, or they will sink into the ground when the weight comes on.

vii. Measures must be taken to prevent uprights being forced in sideways by earth pressure or shell bursts; both the heads and feet must be secured. When round uprights are used they can be notched not more than 1½ inches into the roof supports. When square timber is used the heads and feet should be kept apart by a spreader nailed on; cleats are useless. Notches must on no account be used (Plate 36).

viii. Saw cuts must not be too deep and more must not be notched out than is necessary.

ix. An upright must be provided to support a beam wherever it is crossed by a purlin (Plate 36).

x. Timbers of small scantling, *e.g.* 4 in. by 1 in., 3 in. by 3 in., etc., cannot be expected to carry more than light splinter-proof cover.

xi. Economy in timber is essential, and heavy timbers, *e.g.* 9 in. by 3 in., etc., should not be used when a smaller size will suffice.

6. **Dogs.**—When fastening heavy timbers together, dogs and spikes must not be driven within 3 inches of the edge or 4 inches of the end of the timbers; dogs must be placed on both sides of the frame. Auger holes must be bored for spikes or the latter will split the timbers.

CHAPTER X

SITING AND DEVELOPMENT OF PROTECTIVE WORKS

44. *Siting of fire trenches*

1. Forward and reverse slope positions.—

i. *General.*—A forward slope position is one in which the trenches are on the slope of a hill nearest to the enemy. It is so sited as to give the defender, from his trenches, a clear, uninterrupted view of the enemy's position and the ground over which he must advance to the attack.

A reverse slope position is on the side of a hill farthest from the enemy, and the defenders' trenches are hidden by the contour of the ground from direct ground observation by the enemy.

It is impossible to find a position of any extent in which the slopes are even and uniform. All irregularities of ground present either a convex or a concave surface. These irregularities offer temptations either to go too far forward on a convex slope to obtain a good view, or to draw back too much on a concave slope to escape enemy observation, with the result that pronounced, and therefore inconvenient, salients are formed in the general lines of a position.

In order to avoid these salients, and to make use of those features of the ground which offer the best facilities for defence, it may be necessary to site trenches in one place on a forward slope and in another on a reverse slope.

ii. *Forward slope position.*—Trenches on forward slopes can usually be sited so as to protect observation posts, but care should be taken to ensure they can be adequately protected by artillery fire. When siting foremost positions the probable location of reserves should receive consideration. Communications from front to rear will always present difficulties.

There is a natural tendency to place trenches on high ground, but such ground is not always the easiest to defend successfully; moreover, it is generally easier to provide depth of defence in front of high ground which will be used by artillery and other observers. The advantages of siting trenches on high ground are, that the defender instinctively feels greater confidence, that communications are more easily concealed, that a better view of the enemy is obtained, and

that trenches, usually, are more easily drained. The disadvantages are that slight penetration by the enemy may gain important observation posts, that the defender's fire is more plunging than grazing, that the position of the trenches can be located more easily by the enemy when at a distance, that the assaulting infantry can be supported by the attacker's guns until a later moment, and that the enemy may work round portions of the position and take them in flank and reverse.

iii. *Reverse slope positions.*—When the slopes of high ground are gradual on the defender's side and the crest is broad, it may be desirable to place trenches some distance on that side of the crest. Under these conditions the crest of the hill will screen the trenches from ground observation by the enemy's artillery observers, but it is often difficult to provide the necessary field of fire and observation, and, should the enemy succeed in establishing himself between the crest of the hill and the defender's trenches, the advantage will usually lie with the enemy. Observation over the forward slopes must be obtainable from ground on the flanks or from higher ground in rear, so that effective fire can be brought to bear on the ground over which the enemy must advance. When this is available a reverse slope position is very strong, as the enemy will have great difficulty in arranging his fire plan.

2. Selection of site.—

i. After being given the area of the proposed platoon locality, the position of neighbouring localities and the arcs of fire of any machine guns covering his locality, the platoon commander will select the exact position of his light automatic and rifle posts.

ii. Siting is governed by :—

(*a*) The fire tasks to be carried out.

(*b*) Considerations of such concealment and protection as can be gained from accidents of the ground (Chapters V and VI).

(**Siting must not be governed by any stereotyped ideas of the shape of works gained from diagrams in this or other manuals.**)

iii. Every advantage should be taken of natural concealment or obstacles. Unconcealed section posts with long and wide fields of fire are of little value compared with posts which are concealed from enemy ground observation by hedges or folds in the ground and from enemy air observation by the overhanging foliage of trees, bushes or hedges.

iv. The following points must be remembered in siting trenches :—

(*a*) The field of fire must always be checked by lying on the ground and placing the eyes at the same height as the top of the completed parapet will be. A minimum field of fire of 100 to 150 yards in all directions, and without dead ground, is desirable.

(*b*) The trench must not obstruct the arcs of fire of machine guns or of neighbouring rifle or light automatic posts.

(*c*) Trenches should be so sited as to facilitate enfilade fire.

(*d*) Section trenches must be mutually supporting and sufficiently close to each other to enable the platoon commander to exercise control. The only limiting factor is that they should not be so concentrated as to render them all vulnerable to a single shell burst.

(*e*) Low ground where water may collect should be avoided if possible. The question of drainage must always be considered.

(*f*) As soon as the fire position has been selected it must be marked at once. If not under enemy observation use should be made of flags or other marks which will be visible while siting neighbouring trenches. If in close proximity to the enemy the marking may have to be postponed till nightfall or, alternatively, the whole process of selection and marking may have to be carried out by night, aided by observation from concealed positions during the previous day.

45. *Development of field defences*

1. General.—

i. Field defences will frequently develop as a result of a check in mobile operations in contact with the enemy. This check will generally occur during daylight. It will be impossible to commence any work on forward defences until nightfall, as forward attacking troops will be pinned to the ground by fire, and it will not be possible to bring up tools to them in daylight.

ii. As time, labour and tools will be scarce it is important that any work done during the first night should not be wasted. Subordinate commanders must, therefore, be capable of anticipating the probable lines on which defences will be co-ordinated and developed. These will be laid down as early as possible by higher commanders.

iii. For example, sections and platoons may be in widely scattered positions after nightfall; and if they merely con-

solidate in the position gained, much of the work done may be wasted, for the following reasons :—

(*a*) Some of the posts will have to be abandoned, as the time and labour required to connect them all up would be so great as to postpone for many nights any real improvement of the defences.

(*b*) The bad effect on morale of isolation in small groups of 5 or 6 men in scattered lengths of trench.

(*c*) The fact that the positions in which troops become pinned during a check in mobile operations are unlikely to be the best positions for defending the ground occupied.

(*d*) The fact that sections, platoons, companies, and possibly units, may be considerably mixed up.

iv. Reorganization of the ground occupied into battalion and company sectors and into defended localities will, therefore, be necessary before work is commenced.

Whether it will be possible to carry out detailed reconnaissance and prepare a fully co-ordinated defensive fire plan before the first night's work is commenced will depend on particular circumstances. Whether this is done by the first night or later, there should not, however, be undue hesitation about abandoning small areas of unfavourable ground, subject to conforming with general orders defining the position to be held. Commanders must refuse to be bound by the exact dispositions at the end of a day's fight, if subsequent development of field defences is to be carried out to the best advantage.

It will be a matter of policy for higher commanders to decide whether any digging is to be done or not. It may sometimes be inadvisable to commence digging, as the initial stages of " digging-in " afford an exact picture of the defence to enemy air observation. Units will, however, always commence work as early as possible in the absence of definite orders to the contrary.

2. Sequence of development.—

i. The construction of field defences will generally develop in the following sequence :—

(*a*) Machine-gun emplacements (with some alternative positions or dummies).
Section posts or platoon localities.
Obstacles.

(*b*) Connecting up and deepening section posts within platoon localities. Digging urgently required lengths of communication trench.
Improvement of obstacles.

(*c*) Connecting up platoon localities by trenches which may either be fire trenches or communication trenches.
Further improvement of obstacles, development of communication trenches and improvement of machine-gun emplacements, etc.

(*d*) Connecting up all forward platoon localities between companies and units and further general development of defences and communications.

ii. Completion of trench communications within the platoon and company is the first requirement, but, as more time becomes available, the value of a continuous lateral trench, whether in the form of a front-line trench or further in rear, and later of further lateral communications in rear, should be remembered. The advantages of a continuous front-line trench and lateral communications in rear are :—

(*a*) Morale. They reduce the sense of isolation.

(*b*) They facilitate rapid adjustments of the defensive organization to meet withdrawals from, or additions to, the garrison, and to meet varying conditions of darkness or fog, etc.

(*c*) They increase the enemy's difficulty in locating the exact dispositions of the defence.

(*d*) They result in economy in the length of communication trench required, as one communication trench may be made to serve, for example, two or three company localities if the latter are connected laterally (*i.e.* in the most direct manner).

iii. From the commencement of work on field defences, therefore, it must be remembered that a continuous lateral trench may eventually be desirable. Provided there is no serious difference in tactical value between alternative dispositions, care must be taken to select the one favouring rapid development of field works.

3. Section posts.—

i. The first digging to be done in a position will generally be the construction of section posts (Plate 37). The main object in the construction of a section post should be that the fire task is properly covered. It should generally be possible, if tools are provided after the necessary reorganization of the position, for forward platoons to complete the weapon pits during the first night after a check, without additional labour from reserve platoons, companies or units. If additional labour is allotted it should be employed so that the weapon pits are connected up within the sections during the first

night. If resources permit, work may also be commenced on the interconnection of section posts within platoon localities. Weapon pits and section posts will eventually be deepened into normal fire trenches.

4. **Machine-gun emplacements.**—These need very careful consideration in order to reduce to a minimum the information given to the enemy. Such machine-gun positions as lie within the area of the foremost defended localities must, from the start, be merged into the scheme of section posts so as to be indistinguishable from the air (Plate 21). Cases will frequently occur, particularly if sited in depth, when machine guns are required to fire from comparatively isolated positions. It may then be advisable to postpone digging until the emplacement can be merged into the system of communication trenches or rear defended localities. In any case alternative positions and dummies must be provided as early as possible, and any connecting trenches must always be continued past the emplacement. This continuation must be completed during the same night in which connecting trenches reach the emplacement.

5. **Platoon localities.**—These will generally result from the joining up of section posts by lengths of fire trench connecting forward sections, and of communication trench connecting up rear sections with forward sections and with each other. These communication trenches must be sited so as to get interconnection between sections with the minimum amount of digging. Alternatively a platoon locality may be designed as such from the start. The solution will vary in every particular case.

6. **Communication trenches.**—

Defended localities may be linked up in two ways:—

i. By joining them laterally, and providing a communication trench from rear to front for each group of localities.

ii. By providing a rear to front communication trench for each locality, the localities not necessarily being laterally connected.

The former method is generally preferable, as it simplifies adjustment of the defensive organization, and involves a less amount of digging at each stage of development.

CHAPTER XI

MAINTENANCE AND REPAIRS

46. *Revetment*

1. **Object.**—The object of revetment is primarily to prevent the sides of trenches falling in.

Unrevetted trenches which are exposed to bad weather, or to even moderate shell fire, will soon collapse.

2. **Materials.**—

i. Revetment requires materials such as pickets, brushwood, planks, hurdles, corrugated iron. When these are not issued, local material should be used.

ii. In this section the use of revetment with store materials is explained, and although these are seldom obtainable, men who are practised in their use in peace time will be able quickly to apply the principles to the use of any local material which may be available in the field.

iii. In revetment work there are two parts to consider:—

(*a*) *Firesteps*, or *lower* part of a trench.

(*b*) The *upper* part of a trench.

iv. *Firesteps*, or *lower* part of a trench. Ordinary brushwood packed behind pickets, or brushwood hurdles, planks, sheets of corrugated iron or expanded metal hurdles, supported by pickets or " A " frames are used.

Sandbags should not be used for making or revetting the firestep, as they become very slippery in wet weather.

" A " frames with a trench board on top, as shown in section of a fire trench in Plate 22, Fig. 3, make the best revetment, as they make it easy to drain the trench.

" A " frames will seldom be available except in protracted defence.

Whenever material like brushwood is used to revet the firestep, a plank or pole should be fixed to the top of the pickets, on the edge of the step, to prevent men from treading down the edge of the revetment.

v. The *upper* part of a trench, above the level of the firestep, is most exposed to damage by shell fire and should not be revetted except during extended occupation when ample time and materials are available. Sandbags and brushwood (but not brushwood hurdles) pushed in behind pickets are most suitable, as they can easily be cleared away and replaced, if damaged by shell fire.

vi. For further description of the materials used in revetment, *see* Sec. **6.**

3. Types of revetment.—

i. Revetment can be broadly divided into two types (Plates 38 and 39) :—

(*a*) Those which consist of a " skin " held in position against the face of the earth by fixed uprights—*e.g.* corrugated iron, expanded metal, brushwood or hurdles, supported by pickets or frames.

(*b*) Those which are built up like a retaining wall or dam, and which hold back the earth by their own weight —*e.g.* sandbags, or sods.

ii. *Pickets with brushwood or sheeting* (Plate 38, Fig. 1) :—

(*a*) It is important to see that the feet of the pickets are driven well into sound ground, at a slope of 4/1, and their heads securely anchored back so that the pressure of the earth may not force them out of position. The whole efficiency of the revetment depends on this anchorage.

(*b*) Stout anchorage pickets, at least 2 ft. 6 in. long, should be driven in sufficiently far back from the face of the revetment to be well beyond the angle of repose of the earth (Plate 38, Fig. 1), and at a distance from the face equal to roughly twice the height of the revetment. In soft ground the distance must be increased.

(*c*) The long revetment pickets should be from 2 to 3 ft. apart (depending upon the type of material used, *e.g.* corrugated iron 3 ft. apart, and XPM 2 ft. apart) and wired back to the anchorage pickets by at least 8 strands of wire (14 S.W.G.) twisted together and windlassed tight.

(*d*) These wires should be fastened to the anchorage pickets at ground level and to the top of the revetment pickets, except in the case of breastworks where the wire should be attached to the revetment picket at a point about one quarter of its exposed length from the top (Plate 35).

(*e*) The anchorage wires must be perfectly straight.

(*f*) In very soft ground a second anchorage picket should be driven in 3 or 4 ft. behind the first, and the head of the latter anchored back to it.

(*g*) Anchorage pickets should, as a rule, be driven in or laid at right-angles to the line of pull.

(*h*) Screw pickets when used as anchorages should, on the contrary, be screwed in, in prolongation of the line of pull.

iii. *Brushwood* (Plate 38, Fig. 1) when used in the upper part of a trench should not be made into hurdles, but should be pressed down behind the pickets. Care must be taken that the ends break joint so that the end of one piece of brushwood does not come over the end of the piece below. The leaves and twigs of the brushwood should be removed before being used.

iv. *Brushwood hurdles* will, like other hurdles, be used only for the lower part of the trench. They must be placed behind the pickets, as described above. It is not sufficient to anchor back the pickets of the hurdles themselves. Planking can be used, but not in places where it is likely to be hit by shells.

v. *Corrugated iron* (Plate 38, Fig. 1) makes the neatest and strongest revetment, but it should not be used in the upper half of the trench, as when cut with shell fire it is not easy to remove. The sheets should overlap at the ends for at least 3 in.

In very wet ground holes should be made in the sheets, to act as " weep " holes for the water to drain through.

vi. *Expanded metal hurdles* make a good revetment. They are 6 ft. long and are placed touching only, not overlapping.

Pickets must, therefore, be 3 ft. apart and the hurdles should be tied to them with wire. The XPM, and not the woodwork, should be placed against the earth.

vii. *" A " frames and sheeting or brushwood :—*

(*a*) " A " frames are used for supporting the revetment of the bottom half of a trench, as when revetting the firestep. An " A " frame is shown in Plate 1.

About 3 in. clear is required on each side of the " A " frame in which to put the revetment.

When revetting a fully developed fire trench, the communication part should be dug a foot deeper. (Plate 22, Fig. 3.)

Communication trenches are already dug 6 ft. deep and need not be dug any deeper. (Plate 29, Fig. 2.)

(*b*) Revetting with " A " frames has to be carefully done. All the frames must be vertical and at the same level, or on an even, regular slope.

The distance apart of revetment pickets and " A " frames depends on the stiffness of revetting materials used ; in ordinary ground they should be from 2 to 3 ft. apart when hurdles or brushwood are used.

There must be an " A " frame wherever two of the sheets used for revetment meet, and an " A "

frame at the middle of each sheet. There must also be an "A" frame wherever the trench-boards meet. Trench-boards and XPM hurdles fit together well. The XPM hurdles should be placed touching each other and should not be overlapped. They must be tied by wire to every "A" frame.

(*c*) Corrugated iron sheets are usually more than 6 ft. long, but they can be made to fit by making them overlap as necessary.

The joints of XPM hurdles and corrugated iron sheets on one side of the trench must be exactly opposite, or exactly half way between, the joints on the other side, so that the "A" frames may support them properly.

(*d*) When the "A" frames have been put in and have been proved to be straight and level, the sheets should be put in and pressed down, so that their bottom edge goes right down to the bottom of the "A" frames. Earth must then be poured in behind the sheets and must be rammed hard with pick handles.

(*e*) Corrugated iron sheets are generally less than 3 ft. broad, and planks may then be nailed to the "A" frames above the sheets on the side of the firestep, and also, if available, on the other side of the trench, to bring the revetment up to the right height.

(*f*) In turning the right-angled corners of a traverse with "A" frames, it is ~~essential~~ USUAL that the "A" frame be placed diagonally across the corner so that the trench-boards will be properly supported.

Two ordinary "A" frames can be nailed together and two inner uprights cut, to form the wide "A" frame required diagonally across the corner.

viii. *Sandbag revetment* (Plate 39) :—

(*a*) For revetments, except in the case of damaged parapets, or when silent work is essential, sandbags are expensive, rot quickly and require constant attention.

(*b*) Sandbags should be filled as described in Sec. **6.**

(*c*) The formation, which should be on sound ground, must be sloped at right-angles with the face, as shown in Plate 39, Fig. 1, *i.e.* at a slope of 1/4.

(*d*) The sandbags are then laid in one course with their long sides at right-angles to the wall, and in the next course parallel to the wall, and so on.

Those at right-angles are called "headers" and the others "stretchers."

(*e*) Headers must be laid with their mouths or chokes inside the wall and stretchers with the seam of the bag inside the wall.

The first course at the bottom of the wall should always be made of headers, the next course must be stretchers and so on. The joints in each course must not be over the joints in the course below. Unless the bags "break" joint—the wall has no strength.

(*f*) Plate 39 shows how a sandbag revetment should be built and the kind of mistakes which are often made.

(*g*) The party for filling sandbags should consist of three men ; two men hold and tie the bags while one man shovels the earth into them.

Three men can fill 90 bags in an hour.

For building the men work in pairs, and one pair can lay ~~60~~ 90 sandbags in one hour.

ix. *Sods* (Sec. **6**) should be laid in the same way as sandbags, grass downwards. If available split pickets should be driven, at intervals, through the sods to hold them in position and so strengthen the revetment. Sods are laid at a slope of 3/1, whereas sandbags will stand firmly at 4/1.

47. *Repairs to trenches*

Trenches if not well looked after, or if left unoccupied, will often become unusable from rain and lack of proper drainage. Plate 40, Fig. 1, shows a trench which has become unusable. To make usable and dry, work should be done in the following order :—

i. Dig back the parapet on both sides so as to leave berms 3 ft. broad (a pick's length).

ii. Widen out the top of the trench to 6 ft.

iii. Slope the sides down to the bottom. (Sec. **9**, 6.)

iv. If the mud of the bottom is sticky and difficult to get out, leave it in. Put in the "A" frames, pushing them down into the mud as far as possible, and lay the trench-boards on them as in Plate 40, Fig. 2.

v. Clear the mud from between the "A" frames so as to get a good drain right along the trench.

vi. Deepen the trench and revet it, being careful to leave a 9-in. berm at the top of the "A" frames, as shown in Plate 40, Fig. 3.

CHAPTER XII

PROTECTIVE WORKS FOR ARTILLERY

48. *General*

In mobile warfare the artillery carry out all work concerning :—

i. Concealment of battery positions from ground and air observation.
ii. Protective works in connection with battery positions.
iii. Observation and command posts.

These subjects are dealt with in this chapter, but, in addition, subjects such as slit trenches, revetting and wiring, etc., which are included in other parts of the book, are also of interest to the artillery.

49. *Concealment of battery positions*

1. General.—

i. *Choice of position.*—The possibilities of concealment should be most carefully considered in selecting a position (Sec. **17**).

It is inadvisable to select a position near any natural feature which may facilitate enemy air observers ranging a hostile battery; also the pressure of wheel-tracks near the position will render it liable to air observation.

The initial scheme must allow for the provision of easily hidden approaches to the battery.

If overhead screens and netting are provided for purposes of concealment they should be placed in position before the guns.

ii. *Advantages of broken background.*—The study of air photographs will show the difficulty of hiding a battery in open and broken country.

On the other hand, broken country has many advantages. The many varieties of tone will tend to hide any alterations created by new work. By making use of shadows cast by natural features and of the features themselves, the artificial work necessary may be reduced to a minimum. All work should be sited on the shadow side of natural objects.

Although it is often unwise to choose a hedge in close country the enemy cannot shell all hedges, and concealment in a hedge is better than no concealment from air observation.

Hence, it may be the most far-seeing policy to choose a less favourable position, rather than a naturally perfect but obvious location.

2. Tracks.—The concealment of tracks is considered in Sec. **17**.

3. Regularity of spacing.—In the study of ground from the air, regularity is invariably a sign of man. Regularity of spacing should be particularly avoided, and guns should be unevenly spaced as far apart as is compatible with control and the ground available.

4. Debris.—The presence of spoil is easily detected by an air observer, by reason of its light tone against the background. A scheme for the disposal of spoil must be thought out before any work is commenced, and if overhead cover is to be erected this must be put up before a sod is turned.

All turf should be carefully removed and stacked, to be replaced on the debris when work is finished. It is usually impracticable to remove the spoil from the neighbourhood. Surplus excavation should be collected on the shadow side of any hedges, buildings, etc., and covered with material to blend the heap with the surroundings.

Debris should never be left uncovered, even under overhead camouflage, as the high light reflected from the spoil cannot be cut out by the fabric of the overhead cover.

5. Shadows.—Solid bodies when photographed from the air are generally only recognizable from the shadows they cast.

The most dangerous time for the battery and the most favourable time for the observer is the early morning or in the evening, when the sun is low and the shadows are long.

All excavations cast a distinct form of shadow, and can be identified accordingly without much difficulty.

The risk of detection is lessened by siting the work in broken ground, but whenever any emplacement or excavation is contemplated, and time is available, overhead screening should be erected before any work is commenced. No cover is always better than a bad cover.

For mobile warfare, irregularly spaced guns, covered when not in action by painted scrim, garnished nets, or natural materials such as branches, will probably escape attention if well sited.

6. The flat top cover.—This form of cover consists of a foundation of either string netting or wire netting, having fabric of different natures sewn or tied to it.

Wire netting has the advantage of non-inflammability and is, therefore, preferable for covering guns, at any rate in protracted defence. In mobile warfare, lightness and facility

of handling being important considerations, the adoption of string netting is desirable.

The centre is opaque enough to hide the gun or emplacement underneath, while the fabric thins out towards the edge of the cover. This thinning out blurs the central shadows and at the same time is sufficiently irregular to prevent any defined outline.

There are no sides to the cover, and the intervals between the patches of material allow the light to penetrate and break any shadows caused by the cover itself. The cover is supported on a framework made of posts and wire, having the outside posts staggered. The height above ground varies according to the type of work beneath, but it should be as low as possible. The materials used on the cover vary according to the local conditions.

Owing to the time and labour required to erect this form of cover, it will only be practicable when a halt of some duration is anticipated, unless a folding and rapidly erected overhead screen is used.

The following schedule sets forth various types of cover to suit different kinds of country :—

Nature of ground	Material on cover
Grass country	Strips of green painted canvas knotted on foundations. Dense in the centre. Thinning out to edges.
Grass and earth mixed ...	Large irregular islands of scrim painted earth colour, surrounded by canvas knots.
Shelled area	Large irregular islands of scrim (mud colour) in centre. Smaller patches at edges.
Mining districts	Black and white canvas strips alternating, with a preponderance of black.
Ruins	Red, white and brown strips mixed.
Gorse and heather	String nets placed on irregular framework.

NOTE.—In every case the foundation is the same, *i.e.* string or wire netting on pole and wire frame.

7. Wire netting cover.—This cover is made up with a centre of $\frac{3}{8}$-in. mesh netting surrounded by a fringe of $\frac{1}{2}$-in. netting. A second layer of $\frac{3}{8}$-in. netting is superimposed immediately over the object to be concealed and the cover is then painted as explained below. The cover is designed

mainly against photographic reconnaissance, and is semi-transparent when viewed at low altitudes.

It is essential that the object to be concealed should present a dull surface to the light, otherwise it will be distinguished through the cover, the extent of which is determined by the length of the cast shadow. This type, if properly handled, should throw a shadow of negligible quantity, but if the netting be allowed to sag and thus prevent an opaque surface to the sun's rays this advantage will immediately be nullified.

Up to the present, trials have only taken place over grass and chalk country, and it is therefore impossible to lay down any definite colouring for other forms of background. A very dark, non-reflecting background, such as a spoil bank in a coal-mining district, would be most unsuitable for the employment of this cover, which depends upon reflected light for its opacity.

The degree of efficiency of the cover may be said to depend on the reflective properties of the wire mesh. An all white cover is more opaque than a green ; a black painted netting is valueless, being transparent.

Advantages.—The chief advantages of the wire netting cover over the flat top are :—

i. Its reliability against air stereoscopic photography up to the present. The flat top could almost invariably be detected by this means.
ii. Its non-inflammability.
iii. Its durability.
iv. Its comparative ease in manufacture.
v. The smaller area necessary.

Disadvantages.—The chief disadvantage is the handling of large areas of netting.

Schedule illustrating types of wire cover used on various backgrounds.

Nature of ground	Treatment of cover
Grass land	Cover painted mid-green with a tendency to lighten tone in centre. Edge disrupted by black paint.
Chalk patches and grass land intermingled	Mid-green and white patches, disrupted edge. White patches should be over object beneath cover.
All chalk background, or white metalled road—or concrete...	All white cover.
Sand	Yellow-brown to suit predominant natural tone No confirmation yet obtained by experiment.

8. **Blast marks.**—After firing a number of rounds in the same position blast marks will appear in front of each gun. These are in the shape of white, fan-like patches and are quite unmistakable.

Their presence may be avoided if the situation will allow the battery being sited so as to fire over :—

i. Water.
ii. A metalled road.
iii. Shell-holes.
iv. Rock or limestone.

9. **Blast marks can be hidden by—**

i. Pegging down ¼-in. mesh expanded metal in an irregular shaped patch in front of each gun. One thickness resembles thin grass. Two thicknesses resemble medium grass. Three thicknesses resemble long grass.

ii. By rolling an irregular net of wire or string garnished with canvas knots or patches over the blast mark when the gun has ceased firing. This net must be removed before the gun reopens fire.

10. **Blast marks in snow.**—These appear black fan-shaped patches, and the only sound method of concealment is to cover them with irregular shaped sheets of white calico.

11. **Flash.**—No method has yet been devised of hiding the flash from the air observer.

Screens of brushwood or garnished wire netting may be erected to hide the flash from balloon or ground observers. These screens, however, prove a great source of danger, as owing to their peculiar shadow they are easily recognized by the air observer and on the air photographs, and their presence may lead to suspicion.

12. **Ammunition.**—Any reserve dump of ammunition in the battery position should be sited with great care.

Shells and cartridges should be stacked on the shadow side of hedges, ditches or buildings, and covered with camouflage.

In open country the rounds should be stacked in small irregular heaps unevenly spaced.

As a large amount of traffic must necessarily take place about these dumps, the provision of suitable tracks must be foreseen before the dump is sited.

13. **Personnel.**—The difficulties of concealing a battery position are greatly increased if a large number of men are accommodated in the position.

14. **Dummy positions.**—These have a dual purpose :—

i. To attract the attention of an air observer and thus cause him to overlook an occupied and active battery position.

ii. To simulate a large concentration of artillery by augmenting the batteries already on the spot.

Dummies are invaluable in areas where the absence of suitable natural features renders successful concealment extremely difficult.

If a battery is obliged to take up a position, the approaches to which cannot be concealed from air observation, the only successful solution is a well-defined track passing through the battery to a dummy position at a good distance away.

Hence, given space and time, a dummy position cleverly sited and exploited is an invaluable addition to the concealment scheme.

15. **Construction of dummy position.**—In the construction of a dummy position the following points should be noted :—

i. The dummy must be realistic.

ii. Tracks must be made and maintained. It is not sufficient to make a path and then leave it. A few days' neglect will be noticed on a photograph. Men should be detailed to walk about the dummy position in the day, and at night a wagon should drive up and down the track. Rain also tends to eliminate tracks.

iii. Provision must be made to simulate spoil. Turf must be removed and surface spoil scattered about. Old ammunition boxes, sandbags and other debris can also be distributed.

iv. Dummy blast marks should gradually be made. It is unnatural for well-defined blast marks to appear suddenly. These can be simulated by cutting the grass or removing vegetation from the front of the supposed gun or by laying down painted scrim.

v. Flash screens may be erected, if time permits, in suitable positions calculated to attract attention.

vi. The deception caused by such positions will be short-lived unless live rounds are fired from them occasionally. This should preferably be done when hostile aircraft can observe and on days suitable for sound-ranging. Flash-puffs and bombs may also be usefully employed.

16. **Points special to concealment in mobile warfare.**—

i. *Choice of background.*—The background selected should be broken and full of shadow. Guns should come into action

if possible in shadow, and as much use as possible must be made of natural irregularities, such as bushes, holes and ditches to conceal wagons and personnel.

ii. *Painting of guns and vehicles.*—Experience shows that no painting of standard objects can deceive air observation.

iii. *Gun teams and wagons.*—Wagon lines should be placed in the shadow side of natural features of a sufficient height to cast a suitable shadow.

8. Page 88. Section 50. *Delete* paragraph 1 and *substitute* :—

1. Initial measures.—

Amdt. 2 Mar., 1937

i. In mobile operations, when anything in the nature of an emplacement is out of the question, slit trenches should be dug to provide protection for the command posts and the gun detachments when they are not actually firing the guns. Sec. **38** and Plate 30 refer. When in action detachments will have to rely on the protection afforded by the gun shield and ammunition wagons.

ii. It is important that the slit trenches should be made well outside the arc of movement of the trail, and their position will further be governed by the position of the wagon when the gun is in action.

iii. Command posts should be sited with a view to the employment of any natural cover that may be available, provided that the requirements of the command post as such are not handicapped thereby.

iv. If practicable, covers should be erected over the site of all work *before* any digging is done, and in any case the work should be concealed as early as possible.

1A. More elaborate works.—When operations are sufficiently stabilized, gun emplacements should be constructed and the protective works generally improved. At this stage ammunition wagons will probably not be on the gun positions : ammunition will therefore be stored in recesses in the slit trenches. The latter should now be widened and revetted and, where feasible, provided with weatherproof cover. As the whole position has to be concealed from air observation, it is important to keep the excavations at the gun within as small an area as possible. Plate 41 shows a gun position during the early stages of its development and a method of erecting a cover against air observation

ii. *Ammunition shelters.*—No standard type of ammunition shelter can be laid down. Any existing cover can be utilized, recesses can be dug in banks, or special trenches can be constructed. The following general considerations apply :—

(*a*) Not more than 50 medium, or 100 field, rounds should be kept in any one shelter.

(*b*) Except in the case of fixed ammunition, cartridges must not be kept in the same shelter as shells, and must not be stored inside gun emplacements.

(*c*) Cartridges should be stored about 12 inches above the ground, and should not be exposed to the rays of the sun.

iii. *Improvement of gun emplacements.*—This will be gradual, owing to the amount of labour entailed. Its progress should be guided by the following considerations :—

(*a*) Concealment should be considered before any digging is undertaken.

(*b*) None of the work must interfere with ease in running the gun in or out of its emplacement, or with the provision of an all-round field of fire.

(*c*) Drainage must be provided.

iv. *Improvement of gun platforms.*—This may be effected by the construction of wheel beds and trail supports. The former should be made first, as being generally more important, but both are necessary if prolonged firing is to be carried out from the same position. Except in the case of equipments which are provided with special platforms, wheel beds and trail supports must be improvised from such materials as may be available.

Wheel beds can be conveniently improvised from brick rubble (well rammed) at least 1 ft. deep, or wood. In the latter case it is essential that the baulks of wood be well fastened together.

Trail supports can be made by forming an arc of baulks of wood secured with pickets. To allow of ease in traversing, the spade of the gun should be fitted with a cushion of brushwood or sandbags.

51. *Observation and command posts*

1. Observation posts.—

i. Concealment of an observation post is a consideration second only to that of obtaining an uninterrupted view of the zone over which observation is required. Natural cover will therefore be used wherever possible.

Should it be necessary to improve natural cover, or if no

if possible in shadow, and as much use as possible must be made of natural irregularities, such as bushes, holes and ditches to conceal wagons and personnel.

ii. *Painting of guns and vehicles.*—Experience shows that no painting of standard objects can deceive air observation.

iii. *Gun teams and wagons.*—Wagon lines should be placed in the shadow side of natural features of a sufficient height to cast a suitable shadow.

50. *Protective works in connection with battery positions*

1. Initial measures.—

i. Protective work done in positions which are to be occupied for a short time only should aim at protection of the command post and gun detachments from splinters whilst in action. With this object in view, slit trenches (Sec. **39**) should be dug at once for the command post and detachments, and the earth used to form parapets.

ii. Covers should be erected over the site of the work before any digging is done, if practicable.

iii. Command posts should be sited with a view to the employment of any natural cover which may be available, provided that the requirements of the command post as such are not handicapped thereby.

iv. Initial protection of the gun detachment will entail the provision of a parapet in front of and on the flanks of the gun (Plate 41), and the provision of slit trenches (Sec. **39**) for those members of the detachment who do not stand at, or sit at, the gun in action.

The protection of the detachment of an 18-pr. gun firing off its travelling platform demands special consideration owing to the wide arc through which the gun may expect to traverse. It is important that the slit trenches shall be made well outside the arc of movement of the trail, and their position will further be governed by the position of the wagon when the gun is in action.

2. Subsequent improvement.—Where a position is occupied for some considerable period, the defensive works can be improved as follows :—

i. *Dug-outs.*—

(*a*) Where dug-outs cannot be made shell-proof, men should be accommodated in a number of small dug-outs rather than in one large one.

(*b*) Dug-outs for any personnel not required actually in the position (cooks, etc.) can be sited well clear of the position.

ii. *Ammunition shelters.*—No standard type of ammunition shelter can be laid down. Any existing cover can be utilized, recesses can be dug in banks, or special trenches can be constructed. The following general considerations apply :—

(*a*) Not more than 50 medium, or 100 field, rounds should be kept in any one shelter.

(*b*) Except in the case of fixed ammunition, cartridges must not be kept in the same shelter as shells, and must not be stored inside gun emplacements.

(*c*) Cartridges should be stored about 12 inches above the ground, and should not be exposed to the rays of the sun.

iii. *Improvement of gun emplacements.*—This will be gradual, owing to the amount of labour entailed. Its progress should be guided by the following considerations :—

(*a*) Concealment should be considered before any digging is undertaken.

(*b*) None of the work must interfere with ease in running the gun in or out of its emplacement, or with the provision of an all-round field of fire.

(*c*) Drainage must be provided.

iv. *Improvement of gun platforms.*—This may be effected by the construction of wheel beds and trail supports. The former should be made first, as being generally more important, but both are necessary if prolonged firing is to be carried out from the same position. Except in the case of equipments which are provided with special platforms, wheel beds and trail supports must be improvised from such materials as may be available.

Wheel beds can be conveniently improvised from brick rubble (well rammed) at least 1 ft. deep, or wood. In the latter case it is essential that the baulks of wood be well fastened together.

Trail supports can be made by forming an arc of baulks of wood secured with pickets. To allow of ease in traversing, the spade of the gun should be fitted with a cushion of brushwood or sandbags.

51. *Observation and command posts*

1. Observation posts.—

i. Concealment of an observation post is a consideration second only to that of obtaining an uninterrupted view of the zone over which observation is required. Natural cover will therefore be used wherever possible.

Should it be necessary to improve natural cover, or if no

natural cover exists, the amount of protective work which can be carried out will be limited by the following considerations :—

(*a*) Movement at the observation post such as is demanded by the construction of defensive work will probably only be possible at night.

(*b*) The number of workers available will probably be very small.

ii. When an observation post is to be made in an existing trench system the development of the observation post will be gradual, owing to the above considerations.

Where no cover at all exists, and the observation post is to be occupied for more than one day, the scheme of work must be such that all work visible to the enemy can be completed in the course of one night.

A sketch of an observation post which can be made in about four hours by eight men, is given in Plate 42.

iii. In the forward part of the defensive position, observation posts may take the form of loopholes, but further back it is easier to find hidden positions in buildings, ruins and other features, which will provide the necessary cover, but such places should not be so conspicuous as to draw the enemy's artillery fire. Platforms in trees can be used.

iv. Precautions as stated in Sec. **49** must be taken for concealment of tracks leading to the post.

The loophole of an observation post—even at a distance from the front line—must be hidden by a net (or other means) with patches to make it resemble the surroundings.

v. In constructing an observation post the following points should be borne in mind :—

(*a*) The observer must be comfortable. A shelf, however roughly made, is required in front for his elbows.

(*b*) The post must not be too dark, otherwise the eyes of the observer are strained when he turns his head from the bright daylight outside to the darkness within.

(*c*) The rear of the post must not be open to full daylight whenever any one enters or leaves it, otherwise the enemy may see through the loophole.

(*d*) The bottom of the slit or loophole should be 5 ft. 6 in. from feet level of the observer to enable a tall man to use it, a platform or shelf can easily be made for a short man.

(*e*) The loophole or slit should be irregular in shape and not less than 6 in. high. The breadth of the opening should be 3 in. or larger, according to the extent of ground which the observer has to watch.

(*f*) There should be at least 6 in. of space for the observer's head between the top of the loophole and the roof.

(*g*) The minimum " floor " area in which work can be done properly is 34 sq. ft.

(*h*) The roof should be made splinter-proof. CAMOUFLAGED AND IF POSSIBLE

Amdt. 2 Mar., 1937

2. **Command posts.**—

i. In temporary positions slit trenches will be all that can be provided but covered accommodation should be made as soon as possible. Separate bays of trench, which will have to be widened and revetted and provided with splinter-proof shelters, will be required for :—

(*a*) G.P.O., G.P.O.A. Telephonist.

(*b*) One wireless set.

(*c*) Telephone exchange and one wireless set.

Plate 43 shows a typical design for a battery command post at this stage and Plate 36 gives details of the construction of a shelter.

ii. In protracted defence more elaborate arrangements can be made. The command post should be large enough to contain a map table with telephone, and one bed. The smallest dimensions are 9 ft. by 7 ft. by 6 ft. 6 in. high. A separate dug-out should be provided with a table and two bunks to contain the exchange with, if possible, covered access to the command post. When W/T communication is employed, one set can be accommodated in the telephone dug-out, minimum size 9 ft. by 9 ft. by 6 ft. 6 in., but a separate dug-out may be necessary.

natural cover exists, the amount of protective work which can be carried out will be limited by the following considerations :—

(*a*) Movement at the observation post such as is demanded by the construction of defensive work will probably only be possible at night.

(*b*) [illegible] be very

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should be borne in mind :—

(*a*) The observer must be comfortable. A shelf, however roughly made, is required in front for his elbows.

(*b*) The post must not be too dark, otherwise the eyes of the observer are strained when he turns his head from the bright daylight outside to the darkness within.

(*c*) The rear of the post must not be open to full daylight whenever any one enters or leaves it, otherwise the enemy may see through the loophole.

(*d*) The bottom of the slit or loophole should be 5 ft. 6 in. from feet level of the observer to enable a tall man to use it, a platform or shelf can easily be made for a short man.

(*e*) The loophole or slit should be irregular in shape and not less than 6 in. high. The breadth of the opening should be 3 in. or larger, according to the extent of ground which the observer has to watch.

(*f*) There should be at least 6 in. of space for the observer's head between the top of the loophole and the roof.

(*g*) The minimum " floor " area in which work can be done properly is 34 sq. ft.

(*h*) The roof should be made splinter-proof.

CAMOUFLAGED AND, IF POSSIBLE

2. Command posts.—

i. In temporary positions, slit trenches (Sec. **39** and Plate 30) will be all that can be provided, but covered accommodation should be made as soon as possible.

ii. In protracted defence more elaborate arrangements can be made.

The command post should be large enough to contain a map table and a table for the telephonist, and the smallest dimensions are 9 ft. by 9 ft. by 6ft. 6 in. high.

If possible a separate compartment should be provided for the telephone operator and room for a bed in the command post. A compartment of the size mentioned above will contain a map table and a bed, or telephone table, and two bunks for the operators.

Plate 43 shows various arrangements.

CHAPTER XIII

MISCELLANEOUS PROTECTIVE WORKS

52. *Defence of buildings*

1. General.—Strong, well-built buildings may prove of great value to the defence. On the other hand, poorly built houses without cellar accommodation are seldom worth holding.

2. Preparation of building for defence.—

i. Clearing the field of fire; this may include demolitions of walls, outlying buildings, etc. Care must be taken that when walls and outbuildings are destroyed their ruins do not provide cover for the attackers and that no more are demolished than is necessary. Knocking broad, low holes through the walls will often be all that is needed.

ii. Completion of the defensible perimeter by barricading doors and ground-floor windows which require special treatment, as shown in Plate 44, Fig. 1.

iii. Loopholing doors, windows and walls, so as to provide fire positions for fire in every direction. There should be places from which grenades can be thrown at the attackers.

iv. Obstacles, both at a distance and close to the walls (Plate 44, Fig. 2), should be provided and existing obstacles should be strengthened.

v. Improvement of communications within the building, which may involve knocking holes through walls.

vi. Defence against gas.

vii. Arrangements for storing ammunition, food and water.

viii. Sanitary arrangements and arrangements for wounded.

ix. Supply of water and earth for putting out fires.

3. Doors and windows can be blocked up by nailing planks or corrugated iron on both sides and filling the space between with broken stone at least 6 in. thick. (Plate 44, Fig. 3.) Instead of boards and shingle, the windows or doors may be blocked with a wall of sandbags filled with broken stone. If this is done to a window in the upper floor it will be necessary to strengthen the floor from below with wooden props.

4. Loopholes may be required (Plate 44). Loopholes should be made as far as possible in the doors and windows so as not to weaken the walls.

5. Cellars.—When time is available, full use should be made of cellars. The first essential is to shore up the roof with stout pit-props or frames sufficiently strong to support any protective layer which may be added, as well as the weight of any debris which may be dislodged from the upper storeys.

All cellars should, if possible, have two entrances, protected with gas curtains.

Roofs of brick or concrete will usually be splinter-proof in themselves, but the ordinary timber joist and boarded roof will require the addition of a protective layer as described in Sec. **43, 1.**

Shell-proof protection. In well-built houses, existing walls or roofs act as bursters, and as these are knocked down the covering of the cellar is automatically increased.

53. *Defence of hedges, walls, embankments and cuttings*

1. Hedges.—Hedges and lines of bushes often make good fire positions, as they hide the parapet from the enemy's view.

It is most important to conceal the fact that a hedge is occupied. For this reason the back of the hedge must be thinned in such a way that the upper branches remain as a screen against air observation; the front of the hedge must be cleared in such a way that, though the defender can see and fire through it without being seen, the foliage or branches hide the earth which has been excavated and thrown to the front to make the parapet. The front of the trench must be close to the centre of the hedge, so that its thick stems interfere with the firer as little as possible.

If a ditch is on the enemy's side of the hedges, excavated earth can be thrown into it and then covered with the trimmings of the hedge.

A hedge constitutes a good target and it is often preferable, rather than holding a hedge itself, to site a fire trench in front or in rear of it.

2. Walls, if held, should not be fired over, but loopholes made. Some sort of roof may be required for protection against falling bricks.

3. Embankments and cuttings.—

i. Fire positions can be made in embankments and cuttings by digging T-heads or D-heads (Plate 28).

ii. It is not sufficient to dig a firestep in the slope of a cutting, as firers would in this position be exposed to damage from shells passing over their heads and bursting against the near slope of the cutting. The trench must be dug well outside the cutting and must be joined to the cutting by short communication trenches.

54. *Defence against gas*

1. The entrances to all shelters should, if possible, be provided with gas-tight doors or with curtains of anti-gas material, fitted so as to give a good joint at the sides and bottom of the doorway, thus stopping all draughts. If two curtains are used, with a space between them, complete protection is obtained, and it is possible to enter or leave the shelter without introducing appreciable quantities of gas.

2. A frame of 4-in. by 1-in. timber (Plate 46), covered with anti-gas material, is fixed flush with the wall, sloping outwards at an angle from the vertical. Anti-gas material is cut to the required size, so that when fastened to the top of the frame it will close the entrance completely, with about 9 inches resting on the ground.

Three pairs of laths are nailed horizontally to the curtain to keep it stretched. The lath on the underside must be 1 ft. shorter than the one on the front, so as to clear the frame (Plate 46, Fig. 1). The lowest of the laths should be 4 in. from the floor.

3. Two curtains should be provided. ~~as shown in the diagrams~~. The frame for the inner curtain should slope inwards. All wires and pipes must pass through the frame, which may be widened on one side to allow of this, and the hole through which they pass must be made gas-tight. They must not interfere in any way with the adjustment of the curtain.

The curtains should be not less than 3 ft. apart, so as to allow a man to stand between them and adjust one before raising the other. The distance must be increased for dressing stations to allow stretcher cases to be carried in.

CHAPTER XIV

PROTECTIVE WORKS IN WARFARE IN UNDEVELOPED COUNTRIES

55. *General*

1. The most important differences between protective works used in war against a trained and civilized enemy possessing strong artillery and those used in war against unorganized and uncivilized enemies are, that in warfare against the latter :—

i. Defensive positions take the form of a continuous line of defences round the camp or cantonment, with, in mountain warfare, small posts or forts occupying hills from which, otherwise, the enemy could fire into the camp.

ii. Command, or the height of the parapet above the ground, is of more importance than concealment. Walls or breastworks of stone and other bullet-proof materials can therefore be used instead of trenches. When time permits their construction, small forts or blockhouses are frequently used.

2. The kind of works to be used and the materials to be employed will often be suggested by the customs of the people of the country. Thus, use is made on the N.W. Frontier of India of stone sangars and stone or mud forts ; in Burma and Assam, of stockades or walls of trees or bamboos ; in Africa, of breastworks of sand surrounded with an obstacle made of thorn bushes, called a zariba.

56. *Construction of defences in the desert*

1. These notes apply especially to defences sited in soft desert and sand dunes, when the sand, as regards fluidity, is nearly as bad as water.

Fire trenches which are half trench and half breastwork are generally necessary.

The sides of a trench constructed in sand must consist of a continuous revetment from the bottom of the trench. To make room for the front and rear sandbag revetment and to obtain 3 ft. 6 in. at the bottom of the trench which, after making a firestep of sandbags, leaves a passage of about 18 in., it is necessary to dig the bottom of the trench

6 ft. 10 in. broad (3 ft. 6 in. plus twice 1 ft. 8 in.). The best revetment to use is one of sandbags, although it means digging a wide trench to start with. All sandbags must be doubled (*i.e.* one inside the other).

2. A five hours' task consists of digging a " scoop " or hole 3 ft. deep and building in it a sandbag revetment 3 ft. high along the front of fire bays (*see* Plate 47).

Men should be divided into groups of 10, each party carrying 8 shovels and 1 bale of sandbags (250). As a precaution it is desirable to have 2 picks in addition, in case hard patches are encountered below the surface. Each group is given a frontage of 10 paces, with intervals of 5 paces between groups.

1*st Stage* (about 1 hour). Eight men excavate, throwing sand to the back and front of trench, until the " scoop " is within 6 in. of the bottom of trench, *i.e.* about 2 ft. 6 in. below original surface. Two men double the sandbags ready for filling.

2*nd Stage*. Commence filling doubled sandbags and continue excavating till trench is 3 ft. deep.

3*rd Stage*. Two men laying, 2 men carrying, 6 men filling. The sandbags should be laid to a slope as steep as will ensure the stability of the revetment. If anchored back a slope of 6 in 1 is possible. The angles at the ends of firebays should be revetted and properly secured so that the revetting of the traverse can be carried on subsequently.

During the early stages of the work an extra 2 bales of sandbags should be brought up for each bay, as a total of between 600 and 700 will be required.

CHAPTER XV

ROADS AND TRACKS

57. *General considerations*

1. The importance of good and easy communications in war cannot be over-estimated.

2. All arms should be able :—

i. To construct and maintain cross-country tracks.

ii. To carry out minor repairs to roads, cross simple ditches and remove minor obstacles.

58. *Cross-country tracks*

1. General.—

i. Cross-country tracks are required for the following reasons :—

(*a*) To relieve congestion on main roads.
(*b*) To avoid villages and shelled areas.
(*c*) To improve and shorten communications generally.

All tracks must be reconnoitred, marked, drained and provided with sign-posts.

ii. There are three types of cross-country track :—

(*a*) For men.
(*b*) For pack animals.
(*c*) For animal transport vehicles.

2. Marking of tracks.—

i. All tracks should be marked by means of posts or tapes, or both, or by heaps of stones or earth.

ii. *Posts* should be spaced at intervals (normally about 20 yds.) depending on circumstances.

iii. *Tapes.*—Tapes are only a very temporary expedient: they are soon obliterated by mud.

iv. *Notice boards* should be used in conjunction with the above methods. They have the advantage that each can be marked with the name, letter or number of the track. Black letters on a white ground are better than white letters on a black ground. Notice boards should not be higher than 18 in., or they will be knocked over by passing loads.

Direction boards should be erected at the terminals and at all places where tracks cross lateral routes.

"Up" and "Down" tracks must be clearly marked and the names of any places near which the track passes should be marked on notice boards visible from the track. Map references of important points should be shown on the notice boards.

v. *Lanterns.*—Screened lanterns are useful at junctions and important points. They can be made with candles or small oil lamps in perforated biscuit tins with calico shades.

vi. *Bridges.*—If a small bridge is made, it is important to lay the wooden bearers on a transom (which itself is embedded in the ground) and not directly on the earth; otherwise uneven settlement will occur and the bridge will tilt up sideways.

3. Tracks for men.—

i. *General.*—When making tracks, the following points should be borne in mind :—

(*a*) Each track should be 3 ft. wide to enable men to move along it rapidly on a dark night.

(*b*) A one-way track should be first completed; as soon as possible a duplicate track should be made to give an "Up" and "Down" route.

(*c*) Lateral communication between tracks should be provided, especially in heavily shelled areas.

(*d*) Trench-boards are the most suitable form of track and should be laid on transoms (roughly, 3 in. by 2 in.) bedded in the ground. In swampy ground they should be laid on trestles to keep them above water. Trestles can be constructed of two pickets driven into the ground to support the transom.

ii. *In sandy country.*—A quickly made and efficient track can be made by spreading out rolls of wire netting ($\frac{3}{4}$-in. or 1-in. mesh) on the ground and pegging it down firmly on both sides.

iii. *Tracks for pack animals* consist of an earth formation on the best ground available: the route which involves the least earthwork should be chosen. Points to remember in constructing these tracks include :—

(*a*) The track should be 4 to 5 ft. wide for single traffic and 8 to 10 ft. for double. If less than 4 ft. the mules will slip off.

(*b*) Surface drainage must be provided by means of a ditch on each side of the track.

(*c*) "Up" and "down" single tracks are better than one two-way traffic track.

(*d*) For crossing boggy patches of ground, fascines, brushwood hurdles, or a corduroy of logs are useful.

iv. *Tracks for animal transport vehicles.*—These can be made in the same way as tracks for pack animals. They should be not less than 9 ft. wide for one-way traffic, or 18 ft. wide for two-way traffic.

59. *Emergency road repairs*

1. Ruts and shell-holes.—The rut should be cut out square. If the foundation of large stones has been destroyed, the soling stones should be replaced by hand-packing over which a surface layer of macadam (2 to $2\frac{1}{2}$-in. gauge stones) should be placed and then rammed. The base of the rut should also be rammed before replacing the soling stones.

The earth-berm (*i.e.* the earth part between the macadam and the drain) of a road, even if it is liquid mud, should not be cut away without replacing it with stone, if available, or some other hard material such as chalk or broken bricks, if stone is not available. Shell-holes require similar treatment.

If a hole in a road under traffic is allowed to remain unrepaired even for 24 hours great damage may be caused, as rapid disintegration will take place at the edges of the hole and the foundations may be ruined.

CHAPTER XVI

PASSAGE OF WATER OBSTACLES

60. *General considerations and standard equipment*

1. General.—All arms should be able to construct or make use of the following methods of crossing which are described in Sec. **61** :—

(*a*) Fords.
(*b*) Rafts.

In addition, infantry are responsible for the construction of service assault bridges. A small party of engineers helps to repair and maintain these assault bridges.

61. *Methods of crossing obstacles—Fords and rafts*

1. Fords.—

i. If the bottom is hard and the current not excessive the following depths are fordable :—

	ft.	*in.*
For cavalry	4	0
For tanks (medium tanks)	3	0
(light tanks)	2	0
For infantry	3	0
For motor tractors and field artillery ...	2	6
For motor lorries	2	0
For motor cars	1	6
For motor cyclists	1	0

ii. The width of the ford should be marked by driving strong pickets into the river bed on both sides. These pickets must be long enough for their heads to project 2 ft. above the top of the water.

The tops of the pickets should be joined together by a strong rope. The ropes should be strongly fixed to holdfasts on the banks.

2. Rafts.—The extent of the methods and materials which can be used for making rafts is limited only by the ingenuity of the individual. Infantry may have to cross a river obstacle by means of rafts. These will usually be constructed by engineers, but every opportunity will be taken by infantry in peace to train in their use.

62. *Assault bridging.*

KAPOK ASSAULT BRIDGE EQUIPMENT AND CALCULATIONS

1. Characteristics and component parts.—

i. *Component parts.*—The bridge is made up of :—
Floats.
Transoms.
Deckings.
1½-in. lashings.
(*See* Plate 48.)

ii. *Details.*—Bays are 6 ft. 6 in. The buoyancy of a float in bridge is 300 lb., this will carry one armed man on each float, *i.e.* infantry cross in single file at 6-ft. intervals.

Three bridges can be joined to form one pack bridge, but decking must be improvised. A raft of 32 floats will take 3 tons.

iii. *Weight.*—The weight of each bay, viz. one float, one transom, and one decking, is 1 cwt.

Amdt. 2 Mar., 1937

2. Distribution in the field.—Kapok equipment is held by the corps pontoon bridge park, which carries 702 feet of bridge for each division in the corps.

Additional stocks, varying in quantity, according to the theatre of war, are held in the engineer base store depot.

Note.—The field park company in each division carries a quantity of folding boat equipment.

3. Calculations for amount of equipment required for any given length " L " ft. of bridge.—

i. *For the bridge* :—

$$\left.\begin{matrix}\text{Floats}\\ \text{Transoms}\end{matrix}\right\} \text{ required } = \frac{L \times 2}{13} \text{ minus } 1.$$

$$\text{Deckings required } = \frac{L \times 2}{13} = \text{number of bays.}$$

1½-in. cordage required = L × 12* ft.

Where L = length of bridge in feet.

Pickets 4 + 1 for each side guy.

* For average streams with side guys, every fifth float.

CHAPTER XVI

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For motor cyclists ...	...	...	...	1	0

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Three bridges can be joined to form one pack bridge, but decking must be improvised. A raft of 32 floats will take 3 tons.

iii. *Weight.*—The weight of each bay, viz. one float, one transom, and one decking, is 1 cwt.

2. Distribution in the field.—

		Transport. Light 6-wheelers.
Field squadron	208 ft. 32 bays	2
Field park company	416 ft. 64 bays	4
Pontoon bridge park	832 ft. 128 bays	8
Engineer base store depot.	A variable quantity dependent on the theatre of war.	

3. Calculations for amount of equipment required for any given length " L " ft. of bridge.—

i. *For the bridge* :—

Floats / Transoms } required $= \frac{L \times 2}{13}$ minus 1.

Deckings required $= \frac{L \times 2}{13}$ = number of bays.

1½-in. cordage required = L × 12* ft.

Where L = length of bridge in feet.

Pickets 4 + 1 for each side guy.

* For average streams with side guys, every fifth float.

ii. *For maintenance.*—Proportion of spare material available according to the local conditions and tactical situation.

The material is invulnerable to rifle fire, and cannot be ignited by a tracer bullet, but loses buoyancy if it remains in position over 48 hours.

4. Transport.—

1 L.G.S. wagon will take	78 ft. run.
1 G.S. wagon will take	130 ft. run.
30-cwt. lorry will take	162 ft. run.
3-ton lorry will take	234 ft. run.
Light 6-wheelers will take	98 ft. run. (104 possible.)
Medium 6-wheelers will take	136 ft. run.

KAPOK ASSAULT BRIDGE DRILL

5. General.—For the successful construction and launching of assault bridges with the minimum of delay, it is imperative that the operation should be conducted in the form of a drill. Details of its drill are as follows:—

6. Party required.—

1 commander and 3 supervising N.C.Os.

(For head, centre and tail of bridge), plus :—

Purpose	Men required for					Remarks
	Float	Decking	Side Guy	Transom	Each Bay (Total)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Carrying components to bridge-forming point	2	1	(1) *	(1) *	3	(1) Plus 1 man for every 4 bays or part of 4 bays.
Constructing bridge ...	2	—	1	—	3 (2)	(2) 3 men for each bay, plus 4 extra, 2 at each end of bridge.
Carrying bridge ...	2	2 (3)	1	—	5	(3) This includes spare men to replace casualties. 3 men for each bay is enough when crossing is unopposed.

7. Bridge-forming point.—The method of stacking material at the bridge-forming point is given in Plate 48. The men carrying up transoms are responsible for affixing them to the floats.

8. Drill for construction of bridges.

(1)	Command (2)	Sequence (3)	Numbers affected (4)	Action (5)
1.	—	—	All.	Party formed up facing dump on opposite side of tape marking line of bridge.
2.	"Build bridge"	On completion of 1.	In succession from the right.	Move to dump, each take a length of decking under right arm. Lay along tape, commencing from far end, deckings touching.
3.	—	On completion of 2.	Next in succession (becoming "Float" numbers.)	Working in pairs, take floats and lay at right-angles to tape at decking joints commencing from centre and working outwards. Each pair remains standing by its float.
4.	—	When first three floats are positioned.	Float numbers.	Centre float men fasten decking to centre float.
5.	"In"	After 4.	ditto.	Given by centre men. Float men on either side then position decking, and procedure is repeated till bridge is completed.
6.	—	When all floats are in position.	Next four numbers (2 head, 2 tail numbers).	Each pair take 1 maul, 2 pickets and lashings as ordered. Deposit on bridge.
7.	—	After 6.	Side guy numbers (2 for every 5 bays).	Take side guy lashings and 1 picket. Move to appropriate place in bridge, ready for fixing.
8.	—	When all decking is fixed.	Head numbers.	Lash landing bay at 45° by draw hitch.
			Head and tail numbers assisted by float numbers.	Run a lashing through float handles. 8 yds. spare will be left at each end coiled on end floats.
	—	—	Side guy numbers.	Fix side guys.

(1)	Command (2)	Sequence (3)	Numbers affected (4)	Action (5)
9.	"Prepare to lift and carry bridge."	Zero.	Float numbers. Tail numbers.	Bend down and take hold of float handles. Lift end decking.
10.	"Lift."	On completion of 9.	Float and tail men.	Lift bridge.
11.	"Advance."	Ditto of 10.	All numbers.	Move forward.
12.	"Prepare to lower bridge."	To rest or on reaching bridge site.	All numbers.	Halt.
13.	"Lower."	On completion of 12.	Float and tail men.	Place bridge on ground.
14.	—	On reaching river.	Front two float numbers. Side guy numbers.	Launch front float, then act as launching numbers for other floats. Move up and down stream, guiding bridge.
15.	—	Front 2 floats launched.	Head numbers.	Get on bridge and signal guiding instructions to side guy numbers.
16.	—	On reaching far bank.	Head and tail numbers.	Lower landing bay. Anchor bridge by making fast lashings from landing bays and then through float handles to trees or by lying on the ground with them.
17.	—	Bridge launched.	Float and spare numbers.	Double back to rendezvous.
18.	—	When attackers have crossed.	Head, tail, side guy numbers.	Picket down and remain as maintenance party.

APPENDIX I

TABLE OF MEN, TIME AND TOOLS REQUIRED FOR THE EXECUTION OF CERTAIN FIELD WORKS

NOTE.—The tasks given in this table are those which can be expected from "*average trained infantry working parties*," under the following circumstances—

i. All tracing and marking out has been done beforehand, and the materials are dumped at the site.
ii. The work is carried out by day, or on a clear or moonlit night.
iii. It is not raining.
iv. The march to the work does not exceed 1½ hours.

If the circumstances are not the same as above, *e.g.* if the night is very dark, or rain is falling, or if the troops are tired with fighting or marching, we must expect the troops to do a smaller task.

Item No. (1)	Nature of work (2)	No. of workers (3)	Time (4)	Quantity (5)	Task per man per hour (6)	Tools for party (7)	Remarks (8)
1.	*Earthwork*— Excavation of trenches— (*a*) In soft, sandy ground.	1	1 hour.	30 cu. ft.	30 cu. ft.	1 pick and 1 shovel.	i. The tasks given in col. 5 allow for the earth being thrown out of a trench, 4 ft. deep, to a distance of 8 ft., or, for throwing earth upwards to a height of 6 ft. When the earth has to be thrown further than this, one shoveller should be added for every two diggers.
		1	4 hours.	90 cu. ft.	—	1 pick and 1 shovel.	

Item No. (1)	Nature of work (2)	No. of workers (3)	Time (4)	Quantity (5)	Task per man per hour (6)	Tools for party (7)	Remarks (8)
	Earthwork—contd. Excavation of trenches—*contd.*						
	(*b*) In medium ground, or soft ground with stones or small roots.	1	1 hour.	20 cu. ft.	20 cu. ft.	1 pick and 1 shovel.	ii. When the depth of the trench is more than 4 ft. 1 shoveller should be added for every 2 diggers, to clear the berms and to make up the parapet and parados to to the correct shape.
		1	4 hours.	60 cu. ft.	—	1 pick and 1 shovel.	
	(*c*) In hard ground, or medium soil with stones and roots.	1	1 hour.	15 cu. ft.	15 cu. ft.	1 pick and 1 shovel.	iii. Sticks to clean shovels in wet clay. Crowbars for rocky ground. Hand-axes or billhooks for cutting roots. Spare pick handles, etc., must be provided when required by the nature of the ground.
		1	4 hours.	40 cu. ft.	—	1 pick and 1 shovel.	
2.	Shovelling earth ready excavated.	1	1 hour.	40 cu. ft.	40 cu. ft.	1 shovel.	iv. Allows for 10-ft. horizontal throw.
		1	4 hours.	120 cu. ft.	—		
3.	Excavating earth and loading into wheelbarrows, stretchers, or baskets.	1	—	As	under Serial	No. 1.	v. Spare wheelbarrows, etc., must be available, so that the digger can fill one while the carrier is emptying the other. Sufficient wheelbarrow stretcher or basket men must be allowed so that diggers are not kept waiting.

4.	Moving earth 25 yds., depositing it and returning— (*a*) In wheelbarrows.	1	2 mins.	1 cu. ft.	30 cu. ft.	2 wheelbarrows.	vi. If the distance from the work to the dump is more or less than 25 yds., increase or decrease the time and task accordingly. For example: If the distance is 40 yds. allow $\frac{40}{25} \times 2 = 3\frac{1}{5}$th minutes per cu. ft., or $\frac{120 \times 25}{40}$ = 75 cu. ft. in 4 hours. vii. In calculating the distance, add 5 ft. for each foot of climb for wheelbarrows, and 2½ ft. for each foot of climb for stretchers and baskets. For example: If the distance is 20 yds., and the man pushing the wheelbarrow has to climb 10 ft. the task is worked out as though the distance were 20 yds. plus, 10 × 5 ft. = 37 yds. nearly.
	(*b*) In baskets.	1	2 mins.	⅓ cu. ft.	10 cu. ft.	2 baskets.	viii. Planks are required to make roads for wheelbarrows.
	(*c*) In sandbags (*see* below).	1	4 hours	40 cu. ft.	10 cu. ft.	2 ~~baskets.~~ SANDBAGS.	ix. Wheelbarrows cannot climb a steeper slope than 1/8, or baskets and stretchers a steeper slope than ¼. x. There must be sufficient barrows, etc., so that there is always one being filled while the other is being emptied.

Item No. (1)	Nature of work (2)	No. of workers (3)	Time (4)	Quantity (5)	Task per man per hour (6)	Tools for party (7)	Remarks (8)
	Revetments—						
5.	Sandbag revetment :						
	(*a*) Filling sandbags.	3	1 min.	1 bag.	20 bags.	1 shovel.	xi. Two men holding and tying, one man shovelling. xii. Sandbags to be three-quarters filled (holding ½ cu. ft.). xiii. In calculating tasks for carrying bags calculate distance as for carrying baskets in notes vi. and vii., above.
	(*b*) Carrying sandbags 25 yds., dumping and returning.	1	2 mins.	1 bag holding ½ cu. ft. of earth.	30 bags.	—	xiv. Builders work in pairs when possible. xv. 1 sq. ft. of revetment means 1 sq. ft. measured on the outer face of the sandbag wall. For example : A revetment 10 ft. long and 4 ft. high = 4 × 10 = 40 sq. ft., and would take 1 pair of builders 2 × 40 = 80 mins., and would require 120 sandbags.
	(*c*) Building sandbag revetment.	2	2 mins.	1 sq. ft. of revetment, *i.e.* 3 filled bags.	15 sq. ft. = 45 bags.	1 beater.	xvi. A beater may be either a special wooden beater, or billhook, or a shovel. xvii. The sheeting consists of corrugated iron sheets, XPM hurdles, brushwood hurdles, planks or loose brushwood.
	(*d*) Sod revetment :—						
	i. Cutting sods	3	3 mins.	5 sods.	33 sods.	3 sharp spades.	xviii. Size of sod 18 × 9 × 4½ in. 1 sod to be taken as ½ cu. ft.
	ii. Carrying sods to site, &c.			*See* items above.			

	iii. Building sods	2	3 mins.	1 square foot of revetment	—	1 shovel or spade.	xix. Allow 5 sods, each 18 × 9 × 4½ in. for each sq. ft. of surface revetted 18 in. thick.
6.	Sheeting and picket revetment.	10	30 mins.	10 ft. run.	—	2 mauls, or sledge-hammers. 2 shovels. 1 pick. 1 handsaw. 1 handaxe, or dah. 1 pair pliers. 1 crowbar (in rocky soil).	xx. Distribution of working party :— 2 men driving anchorage pickets. 2 men driving revetment pickets. 2 men placing sheeting. 2 men wiring pickets. 2 men trimming and filling. xxi. With a smaller working party, allow longer time.
7.	Sheeting and "A" frames.	7	30 mins.	10 ft. run of trench.	—	2 picks. 2 shovels. 2 mauls. 1 handsaw. 1 hammer. nails.	xxii. The time given does not include digging out the trench to full section. In a fully developed fire trench (Plate 22, Figs. 2 and 3) we must allow time and tools for digging out 4 cu. ft. per foot-run of trench. xxiii. The sheeting consists of corrugated iron sheets, XPM hurdles, brushwood hurdles, planking or brushwood. xxiv. For each corner add 15 minutes to time required for revetting the trench. xxv. Distribution of parties : 2 men supply materials. 3 men placing frames and sheeting. 2 men trimming and packing (*see* Note xxi., above).

Item No. (1)	Nature of work (2)	No. of workers (3)	Time (4)	Quantity (5)	Task per man per hour (6)	Tools for party (7)	Remarks (8)
8.	Laying trench-boards on "A" frames.	3	10 mins.	10-ft. run of trench.	—	1 saw. 1 hammer. nails.	xxvi. Work carried out as described in Sec. **46.** xxvii. Add 10 minutes for each corner. xxviii. 2 men laying and fitting. 1 man supplying material.
9.	Picket trestles and laying trench-boards on same.	5	10 mins.	6-ft. run of trench-boarding.	—	1 maul. 2 handsaws. 2 hammers. nails.	xxix. Pickets distributed on site. xxx. Trestles at 3-ft. intervals.
10.	Making brushwood hurdles.	3	20 mins.	1 hurdle.	—	2 billhooks or hand-axes. 1 pair of pliers.	xxxi. Hurdle is made as described in Sec. **6,** 14.
11.	Making fascines.	4	1 hour.	1 fascine.	—	3 billhooks or hand-axes. 1 handsaw. 2 knives. 1 pair of pliers. 1 maul. 1 fascine choker.	xxxii. The fascine is made as described in Sec. **6,** 15. A fascine choker consists of 2 stout wooden handles, 4 ft. long, connected by a 2-ft. length of chain. One end of the chain is fastened to each handle at a point 18 in. from one end of the handle. It will have to be improvised. xxxiii. The frame on which the fascine is made is assumed to have been already prepared.

							xxxiv. The materials required for a fascine 18 ft. long and 9 in. in diameter are— Brushwood, 200 lb. Wire, 60 ft. For making the frame, 10 pickets, 6 ft. 6 in. long and 3 in. in diameter, are required.
12.	Felling trees.	1	1 min.	1 in. of diameter of tree up to 12 in. If over 12 in. diameter allow time in minutes $= \frac{d^3}{144}$, where d = mean diameter in inches.	—	1 felling-axe or hand-saw.	xxxv. This means that 1 man can fell a tree 9 in. in diameter in 9 minutes. If only hand-axes are available the time should be doubled. Over 12-in. diameter the time required is much greater. The hand-axe is not suitable for trees more than 15 in. in diameter. To fell a tree it should, if possible, be strained in the required direction of fall by a rope. It is then cut half through on that side and finished off by cutting about 4 in. higher up on the opposite side. If a saw is used, it is essential to keep the cut open, either by wedges, or by straining, or by using the natural lean of the tree.
13.	Cutting brushwood.	1	1 hour.	25 sq. yds.	—	1 hand-axe or billhook.	xxxvi. Diameter up to 2½ in.

Item No. (1)	Nature of work (2)	No. of workers (3)	Time (4)	Quantity (5)	Task per man per hour (6)	Tools for party (7)	Remarks (8)
14.	Loopholing brick walls— Making loopholes in brick walls up to 18 in. thick.	1	30 mins.	1 loophole.	2 loopholes.	1 pick or 1 crowbar.	xxxvii. Add 50 per cent. to the time if in cement mortar. xxxviii. A mason's hammer and chisel are the best for this work.
15.	Making notches in a wall up to 18 in. thick.	1	10 mins.	1 notch.	5 notches.	1 pick or 1 crowbar.	xxxix. Notches are "V"-shaped loopholes made in the top of a wall.
16.	Wire obstacles— Making concertinas.	3	20 mins.	1 concertina.	—	9 long pickets. 1 sledge-hammer. 1 frame for head of pickets (*see* Plate 25). 1 pair of pliers. 1 windlass stick.	xl. For method of making concertina, *see* Sec. 30. xli. The stores required for one concertina are :— 1 coil of barbed wire (130 yds.). 18 yds. No. 12 binding wire (or 36 yds. of No. 14). 50 ft. thin binding wire, cut in 4-in. lengths. Two 5-ft. laths or bamboos. String.
17.	Double belt of concertinas (Plate 26).	1 N.C.O. and 7 men.	Day— 20 mins.	50 yds.	—	1 pair of pliers. 7 windlass sticks.	xlii. Drill for erecting concertina fence is given in Sec. 30.

			Night— 30–35 mins.				xliii. Stores for 50 yds. of double belt are :— 34 long pickets. 4 anchorage pickets. 16 concertinas. 2 coils of 130 yds. of barbed wire.
18.	Making coils of "loose" wire.	2	5 mins.	1 coil of "loose" wire.	—	4 3-ft. pickets. 1 maul. 1 pair of pliers.	xliv. For method of making coils of "loose" wire, *see* Sec. 31. xlv. The stores required for 1 coil of "loose" wire, sufficient for a bay of 2 yds. wide and 25 yds. long, are :— 1 coil of 130 yds. of barbed wire. String.
19.	Double belt of "French" wire.	1 N.C.O. and 7 men.	Day— 15 mins. Night— 20–30 mins.	50 yds.	—	1 pair of pliers. 7 windlass sticks.	xlvi. No drill is laid down for erecting "French" wire, but that given in Sec. 30 can be adapted. xlvii. The stores for 50 yds. of double belt, with loose wire between belts are :— 26 long pickets. 4 short pickets. 6 coils of "French" wire. 3 coils of 130 yds. barbed wire. 2 coils of "loose" wire. 24 staples.

Item No. (1)	Nature of work (2)	No. of workers (3)	Time (4)	Quantity (5)	Task per man per hour (6)	Tools for party (7)	Remarks (8)
20.	Wire obstacles—*contd.* Standard double apron fence (Plate 9).	1 N.C.O. and 10 men.	Day—30 mins. Night—45–60 mins.	50 yds.	10 yds.	1 pair of pliers. 10 windlass sticks. Gloves, if desired.	xlviii. Drill for erecting double apron fence is given in Sec. 28. xlix. Stores for 50 yds. of double apron fence are :— 20 long pickets. 40 short pickets. 9 (65 yds.) coils of barbed wire. 2 (130 yds.) coils of barbed wire (for diagonals). (For practice or rapid work 13 coils of 65 yds. of wire can be used.)
21.	Wire tree-entanglement in thick undergrowth.	8	20 mins.	50 yds.	—	2 billhooks or hand-axes. 2 pairs of pliers 5 50-yd. coils of barbed wire.	—

APPENDIX II

Table of Tools Carried in the Field

A.—Other than those allowed for machine guns or as vehicle or tank equipment.

(1)	Cavalry brigade (2)	Cavalry regiment (3)	Horse Artillery battery (4)	18-pr. battery (5)	4·5-in. howitzer battery (6)	Light battery (7)	60-pr. battery (8)	6-in. howitzer battery (9)	Heavy battery (10)	Anti-aircraft battery (11)	Field squadron, R.E. (12)	Field company, R.E. (13)	Field park company, R.E. (14)	Army troops company, R.E. (15)	H.Q. infantry brigade. (16)	Infantry battalion. (17)	Tank battalion. (18)	Divisional reserve (*a*) (19)
Axes, felling	—	14	6	6	6	4	8	8	12	8	64	49	18	36	—	16	16	—
,, hand	1	7	—	—	—	4	—	—	—	—	48	40	10	36	1	8	16	—
,, pick	160	12	36	36	42	16	4	4	36	24	79	107	49	98	550	76	3	435
Crowbars	—	3	3	3	3	2	2	2	6	6	12	8	4	8	2	8	3	—
Hooks, bill	—	12	18	18	21	8	4	4	12	24	40	39	16	20	—	20	—	—
,, reaping	4	36	12	12	12	48	—	—	12	—	16	13	10	6	—	20	—	—
Sandbags...	—	—	—	—	—	—	—	—	—	—	200	400	400	800	—	—	—	—
Saws, cross-cut	—	—	—	—	—	—	2	2	2	—	8	4	6	12	—	—	4	—
,, folding	—	3	6	6	6	4	4	4	6	—	12	4	4	—	—	12	—	—
,, hand	—	4	18	18	21	4	4	4	6	10	40	35	35	67	—	1	21	—
Shovels	300	18	36	36	42	48	16	16	48	24	96	111	60	122	840	100	3	860
Spades	—	—	30	30	36	—	4	4	48	24	8	10	10	16	—	10	—	—

(*a*) Carried by Field Park Coy., R.E.

APPENDIX II—*continued.*

B.—Cart, wagon and machine-gun equipment.

Detail (1)	Axes, felling (2)	Axes, pick (3)	Hooks, Bill (4)	Shovels (5)	Spades (6)
Carts, Maltese	1	1	1	2	—
,, officers' mess	1	—	1	—	—
,, water	—	1	—	1	1
Wagons, telephone	1	1	—	—	—
Machine guns—					
Vickers, for each gun	—	1	1	2	—
Lewis (infantry) for every 8 guns ...	—	4	—	4	—

APPENDIX III

Organization of Tracing Parties

1. The organization of a tracing party given below applies to taping fire trenches, but may be modified for other purposes. The party should be divided into groups as follows :—

i. *Fire bays.*—An officer and 1 N.C.O., with extra men as carriers. The officer traces out the fire bays, driving in pegs at the end of each ; the shape of the ground must, of course, be borne in mind in selecting the fire bays.

ii. *Traverses.*—An experienced N.C.O. and 2 men, with extra carriers if necessary. The N.C.O. pegs out the traverses.

iii. *Clearing.*—A number of men, varying with the nature of the ground, to clear crops, bushes, etc., from the line of the tape.

iv. *Taping.*—One N.C.O., with carriers for tape, running out the tape and fixing it to the pegs.

2. The duties of the various groups are tabulated below :—

Group (1)	Composition (2)	Tools and stores (3)	Duties (4)
No. 1 Group ...	1 officer, 2 or 3 men.	1 mallet and bundles of pegs.	Peg out fire bays.
No. 2 Group ...	1 N.C.O., 2 to 4 men.	1 mallet and bundles of pegs.	Peg out traverses.
No. 3 Group ...	Reaping, as required by nature of ground.	Re-opening hooks, bill-hooks, etc.	Clear line for tape.
No. 4 Group ...	N.C.O. and 2 or 3 men.	Tape.*	Fixing tape to pegs.

* Tracing tapes are generally supplied in 50-yd. lengths.

APPENDIX IV

Load Tables

Articles	One-man load		Vehicles		
	No.	Weight, lb.	3-ton (*a*) lorry	G.S. Wagon	Limbered G.S. Wagon
(1)	(2)	(3)	(4)	(5)	(6)
" A " frames (small)	1	30	120	40	40
Axes, pick, 8 lb. complete	4	32	700	240	224
,, ,, with heads and helves separate	—	—	840	350	280
Bags, sand, common (in bales of 250)	—	—	15,500	7,500	3,000
Board, trench ... ... 6 ft. long	1	35	120–150	35–40	20
Canvas, Hessian, roll ... 3 ft. wide, 110 yds. in roll	50 yds.	32	80	27	20
,, rot-proof, roll... 5 ft. wide, 120 yds. in roll	30 yds.	32	40	14	14
Cement, cask ... ... 400 lb.	—	—	14	5	4
Chalk, sand, gravel	½ Sand Bag		2½ cub. yds.	¾ cub. yd.	¾ cub. yd.
Earth	½ Sand Bag		2½ cub. yds.	¾ cub. yd.	½ cub. yd.
Felt, roll ... ... 3 ft. wide, 25 yds. in roll	10 yds.	35	66	22	22
Iron, corrugated, 6-ft. sheets Width, 2 ft. 2 in.	2	32	350	120	120
,, ,, 7-ft. sheets ,, ,,	1½	27	300	100	100
,, ,, 9-ft. sheets ,, ,,	1	28	200	70	—
Joists, steel, rolled, 9 ft. by 5 in. by 3 in. ... 100lb.	—	—	56	19	—
Metal, expanded, sheets (6 ft. 6 in. by 3 ft.) in cases of 20 sheets	1	27	200	70	80 sheets
*Nails	—	—	—	—	—
Pickets, angle, long ... ... 6 ft. long	2	28	400	150	130
,, ,, medium ... 3 ft. 6 in. long	4	36	700	250	200
,, ,, short ... ... 2 ft. long	8	38	1,350	500	400

Pickets, brushwood, long 5 ft long, 3½–4 in. diam.	4		36	600	200	150
,, ,, short 2 ft. 6 in. long, 2½–3 in. diam.	3		30	1,800	600	500
Posts, screw, wire entanglement, Type " A," long	4		34	650	390	200
,, ,, ,, " B," short	10		34	1,640	980	550
Prop, pit, 9 ft. long ... ...6 in. in diam.	—		—	75	25	—
,, ,, ...9 in. in diam.	—		—	36	12	—
Shelter, steel, corrugated, large	—		—	1	½	—
,, ,, small	—		—	5	1	1
Shovels, G.S.	10		37	1,500	400	300
,, R.E.	7		35	1,050	220	140
†Staples, No. 8 S.W.G.	—		—	—	—	—
Tapes, tracing ... ... in 50-yd. rolls	12		—	—	—	—
Timber, 4 in. by 2 in. ... ... 2½ lb. per ft. run	—		—	2,250 ft. run	750 ft. run	600 ft. run
,, 9 in. by 3 in. ... ... 9 lb. per ft. run	—		—	600 ft. run	200 ft. run	120 ft. run
Wire, barbed, coils (28 lbs. each) ... ... coils	1		28	200	70	~~72~~ 50
,, entanglements (French) (bundles) weight of coil about 19½ lb.		2	coils	400 coils or 80 bundles	150 coils or 30 bundles	50 coils
,, ,, (French) spikes ... 100	100		32	—	6,000	6,000
,, ,, (French) staples boxes of 300	—		—	35 boxes	12 boxes	12 boxes
,, galvanized, iron, coil ... ...No. 14 S.W.G.		½	coil	100 coils	40 coils	34
,, netting, roll ... 3 ft. wide, 50 yds. in roll	20 yds.		32	70	24	24

(*a*) The 30-cwt. lorry will take half the load of a 3-ton lorry.

* Nails, 1 inch=800 to 1 lb.; 2 inch, 122 to 1 lb.; 3 inch, 52 to 1 lb.; 4 inch, 30 to 1 lb.; 5-inch, 20 to 1 lb.; 6-inch, 14 to 1 lb.

† Staples, No. 8 S.W.G., 50 to 1 lb.

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—— Combatant troops, necessity for use of 1
—— Digging : extension of on work 27
—— Officer i/c : duties etc. 22
—— Organization of ... ... 25 *et seq.*
—— To be complete units or sub-units 25

Z.

Zariba, use of 95

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FIG. 1.—SMALL "A" FRAME

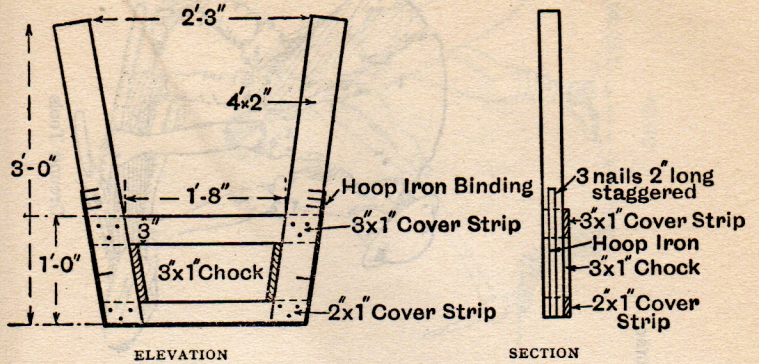
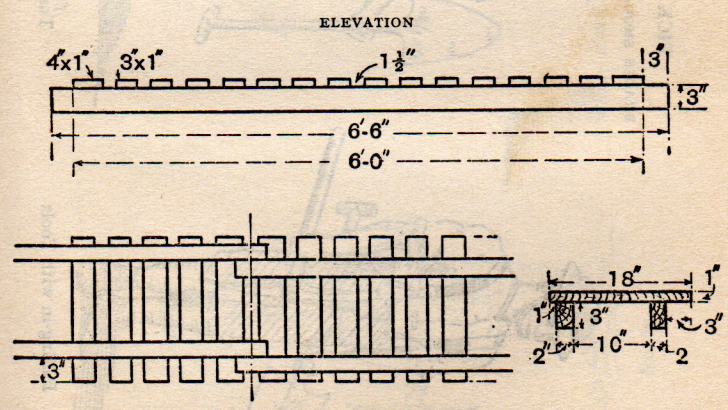


FIG. 2.—TRENCH-BOARD



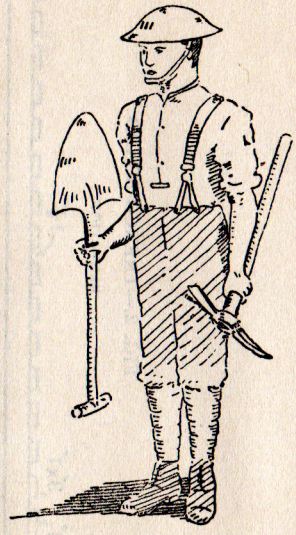
NOTE.—*One of the best methods for preventing Trench Boards from becoming dangerously slippery when muddy and wet, is for each slat or tread to have a straight piece of No. 5 B.W.G. wire fastened along the top of its centre by not less than 5 staples.*

PLATE 2.

PICK AND SHOVEL DRILL

BRACES SHOULD BE REMOVED WHEN DIGGING

Falling-in with Tools



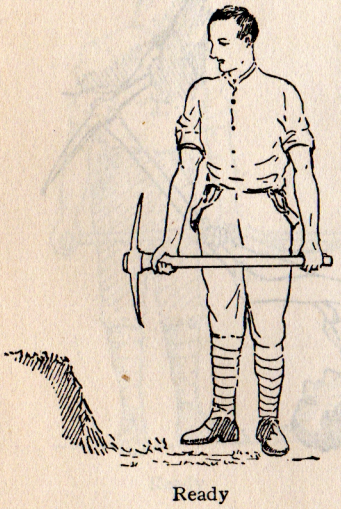
Turning with Tools

Ground Tools

[See Sec. 8, 2.

See Sec. 8, 4.]

USE OF PICK



Ready

Raise

Strike

PLATE 3.

USE OF PICK

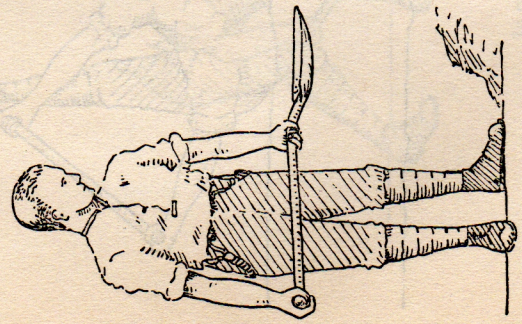
Rake

Break

USE OF SHOVEL

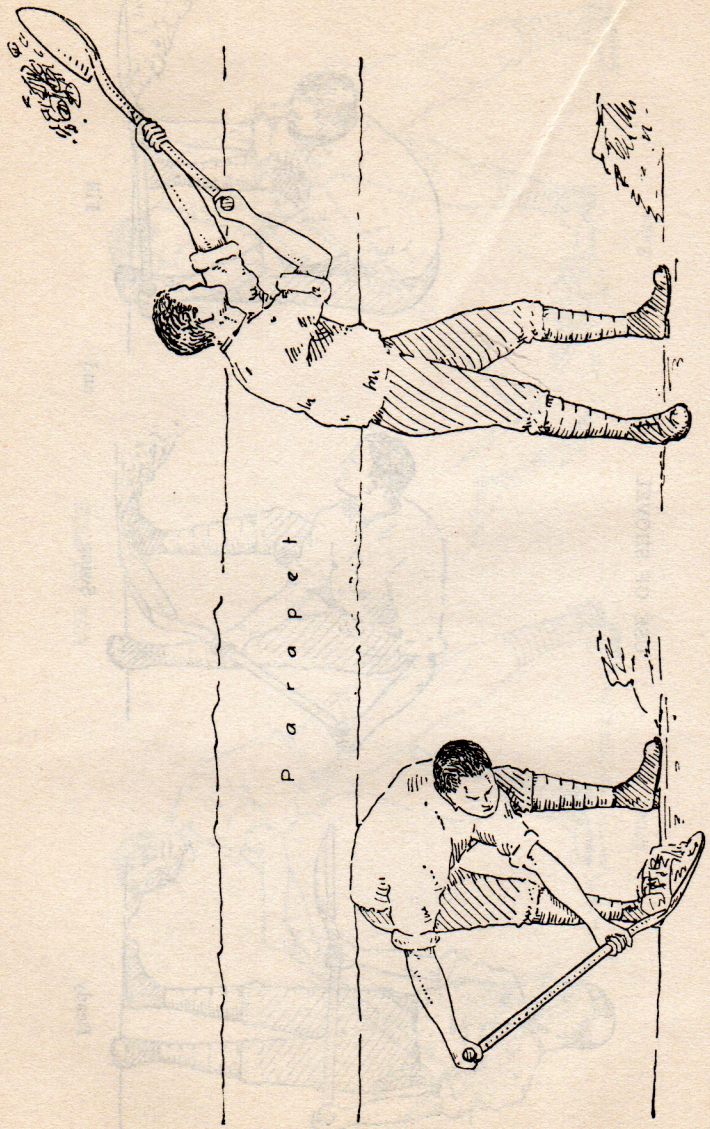
Fill and

Swing



Ready

USE OF SHOVEL



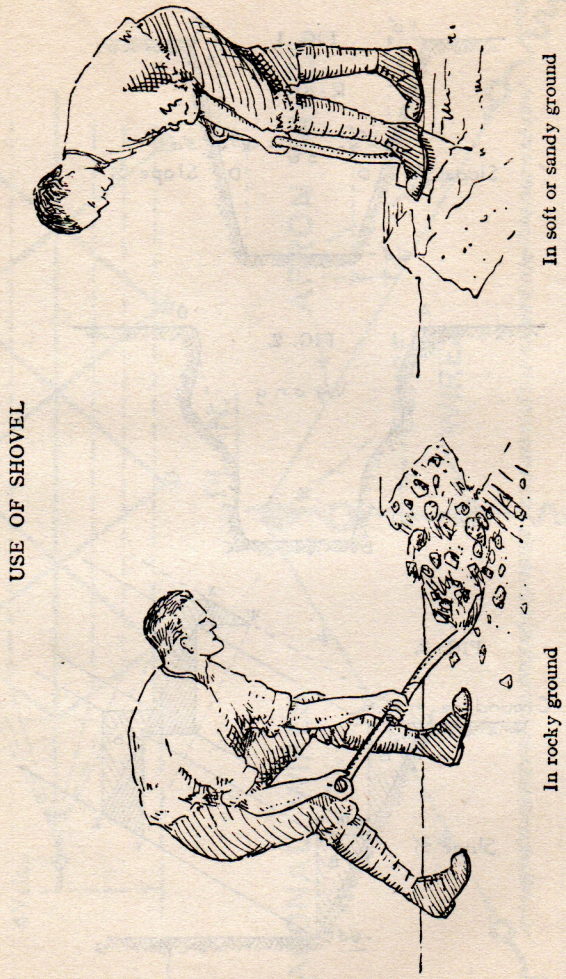
Throw

and

Swing

NOTE.—During this movement the helve should be allowed to slide through the left hand.

USE OF SHOVEL



In soft or sandy ground

In rocky ground

METHOD OF SLOPING SIDES OF A TRENCH

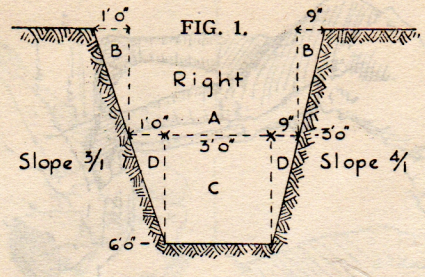


FIG. 1.

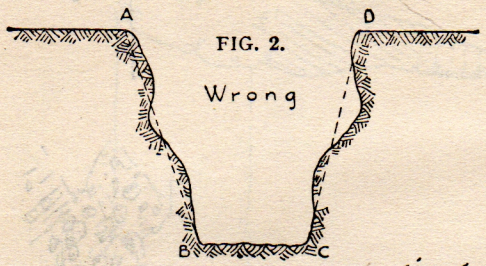


FIG. 2.

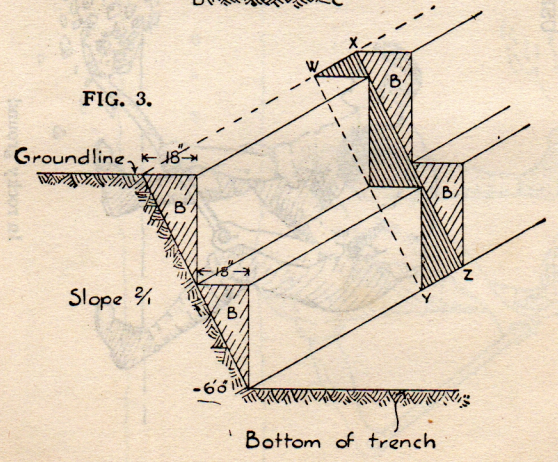
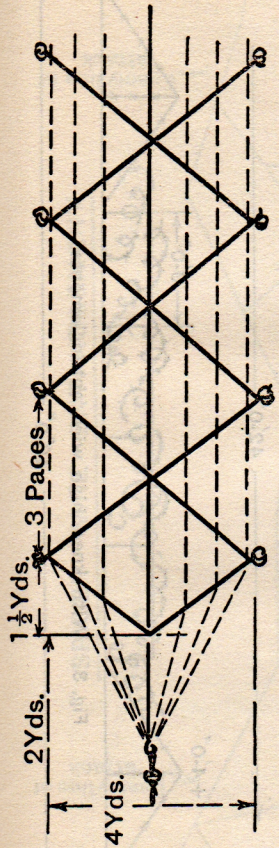
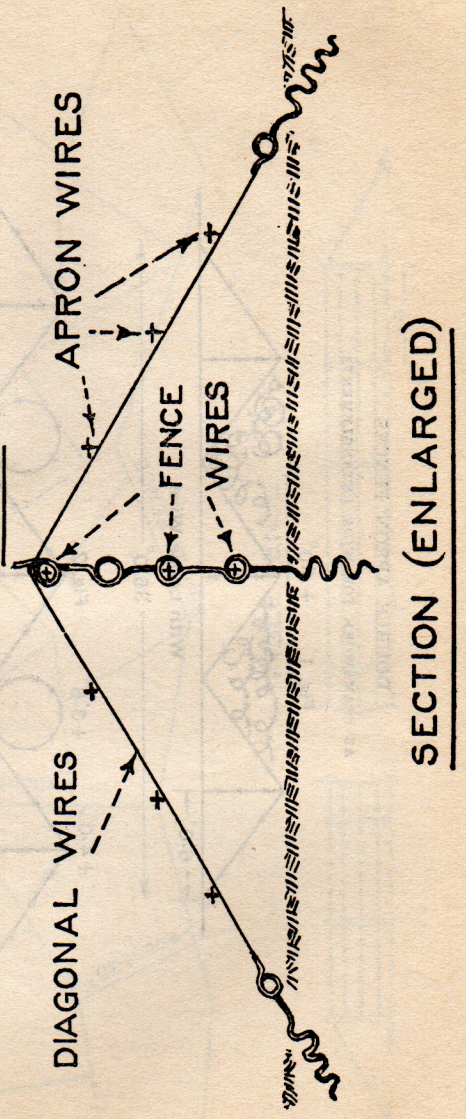


FIG. 3.

DOUBLE APRON FENCE



PLAN.



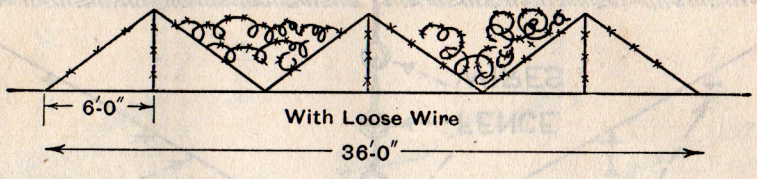
SECTION (ENLARGED)

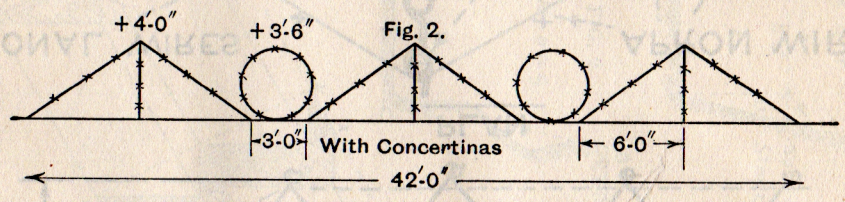
PLATE 10.

DOUBLE APRON FENCES

AS FRAMEWORK FOR WIDE ENTANGLEMENTS

Fig. 1. +4'-0"





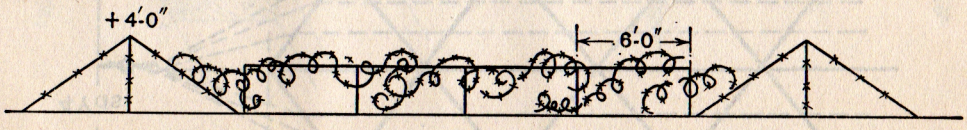
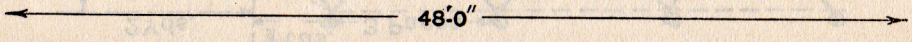


Fig. 3. With knee high wire entanglements.

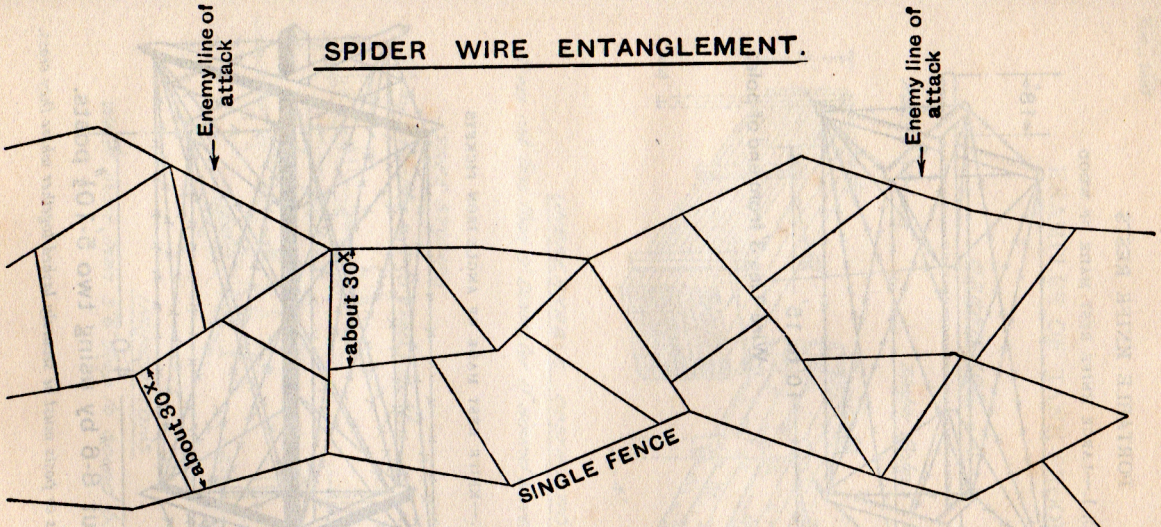


[*See Sec.* **21**, **2**.

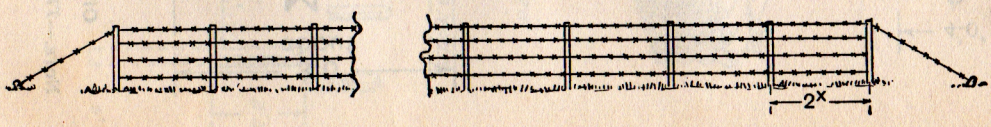
[*See Sec.* **21**, **4**.

PLATE 11.

SPIDER WIRE ENTANGLEMENT.



SINGLE FENCE



PORTABLE KNIFE RESTS

FIG. 1.—LARGE KNIFE REST MADE OF WOOD

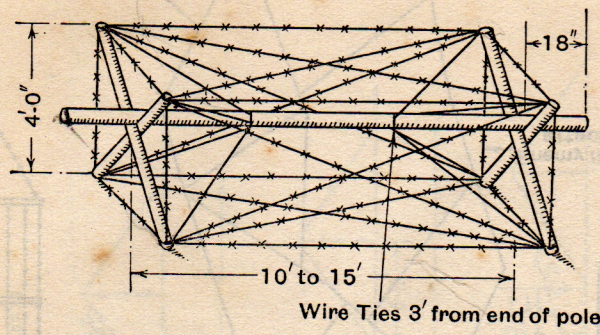
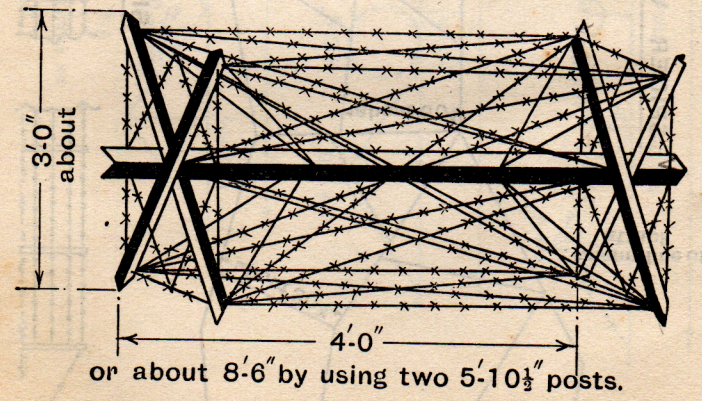


FIG. 2.—KNIFE REST MADE OF ANGLE-IRON PICKETS

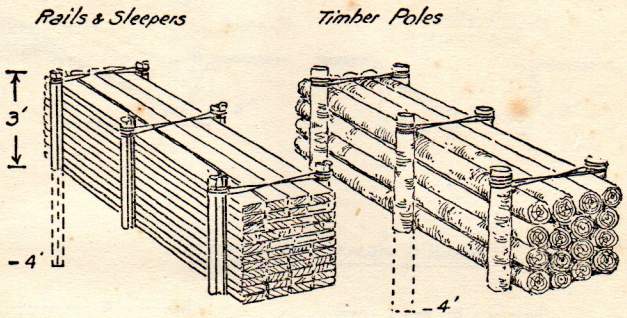


NOTE.—*The pickets or posts must be securely lashed together where they cross.*

Amdt. 2
Mar., 1937

EXAMPLES OF TANK-PROOF OBSTACLES.

BARRICADE

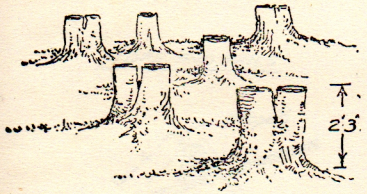


UNBREAKABLE OBSTRUCTIONS

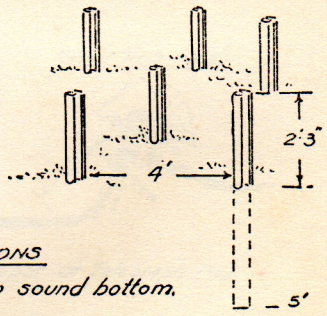
Trees not less than 9" Diameter if sound & well rooted.

TREE STUMPS

Stumps must be cut to exact height.



80 LB RAILS.

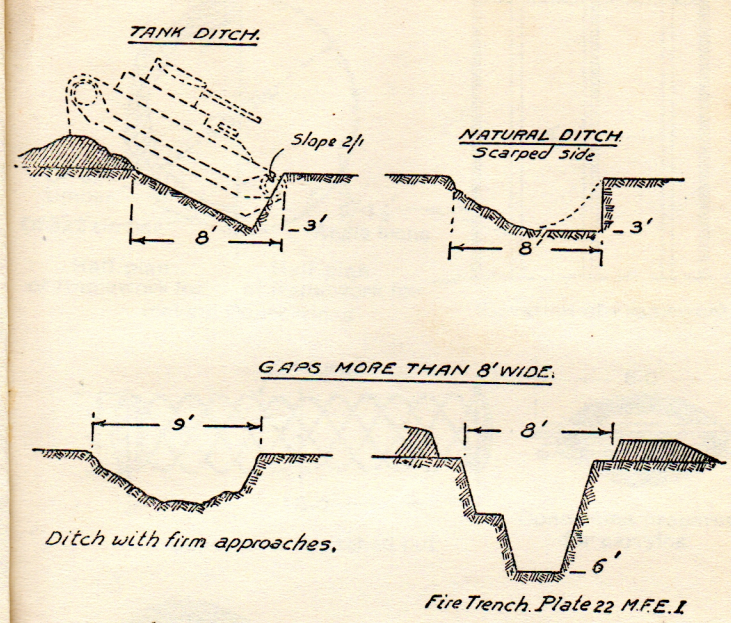


INUNDATIONS

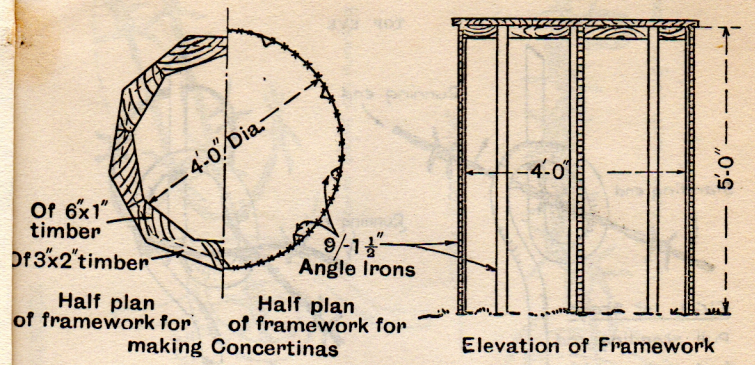
Water more than 3'6" deep to sound bottom.

PLATE 13B. Amdt. 2 Mar., 1937

EXAMPLES OF TANK-PROOF OBSTACLES.



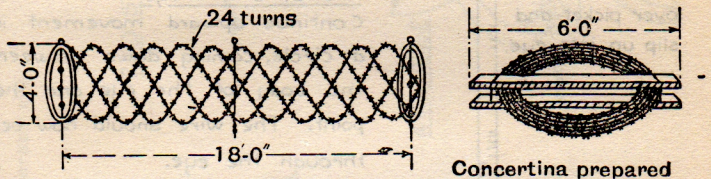
BARBED WIRE CONCERTINAS



Half plan of framework for making Concertinas

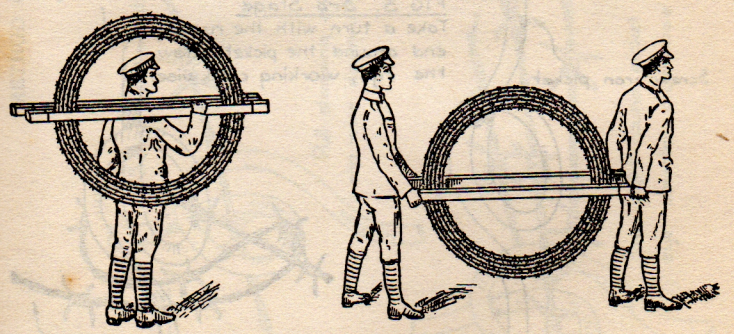
Half plan of framework for making Concertinas

Elevation of Framework



Concertina stretched out

Concertina prepared for carrying



Sketch showing one man carrying Concertina on shoulder.

Sketch showing two men carrying Concertina.

METHOD OF FIXING WIRE TO PICKETS

TOP EYE

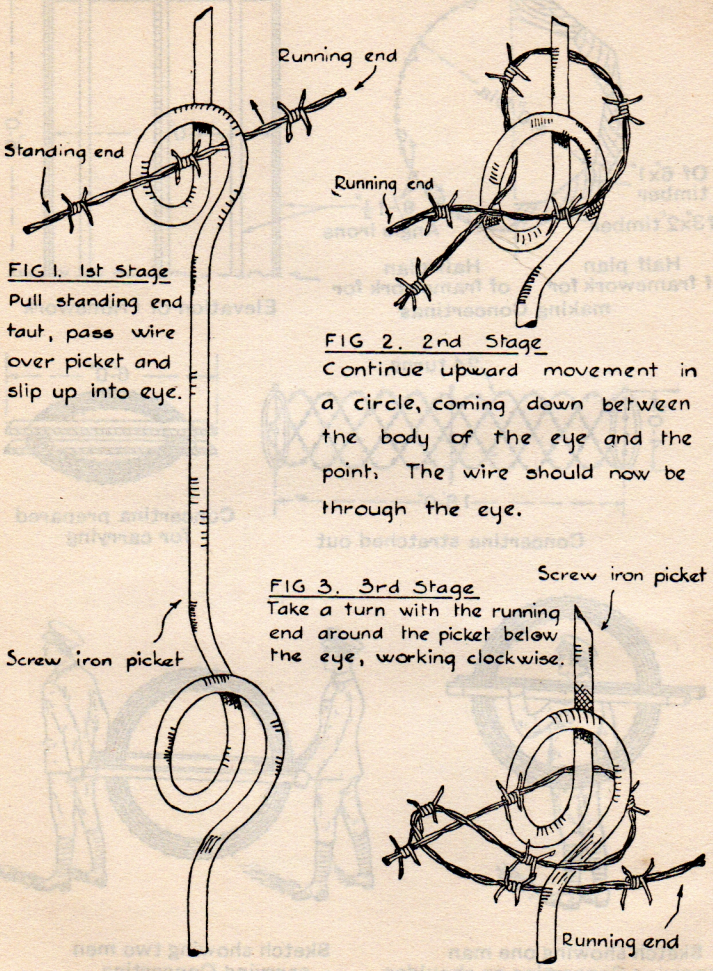


FIG 1. 1st Stage
Pull standing end taut, pass wire over picket and slip up into eye.

FIG 2. 2nd Stage
Continue upward movement in a circle, coming down between the body of the eye and the point. The wire should now be through the eye.

FIG 3. 3rd Stage
Take a turn with the running end around the picket below the eye, working clockwise.

METHOD OF FIXING WIRE TO PICKETS

OTHER EYES

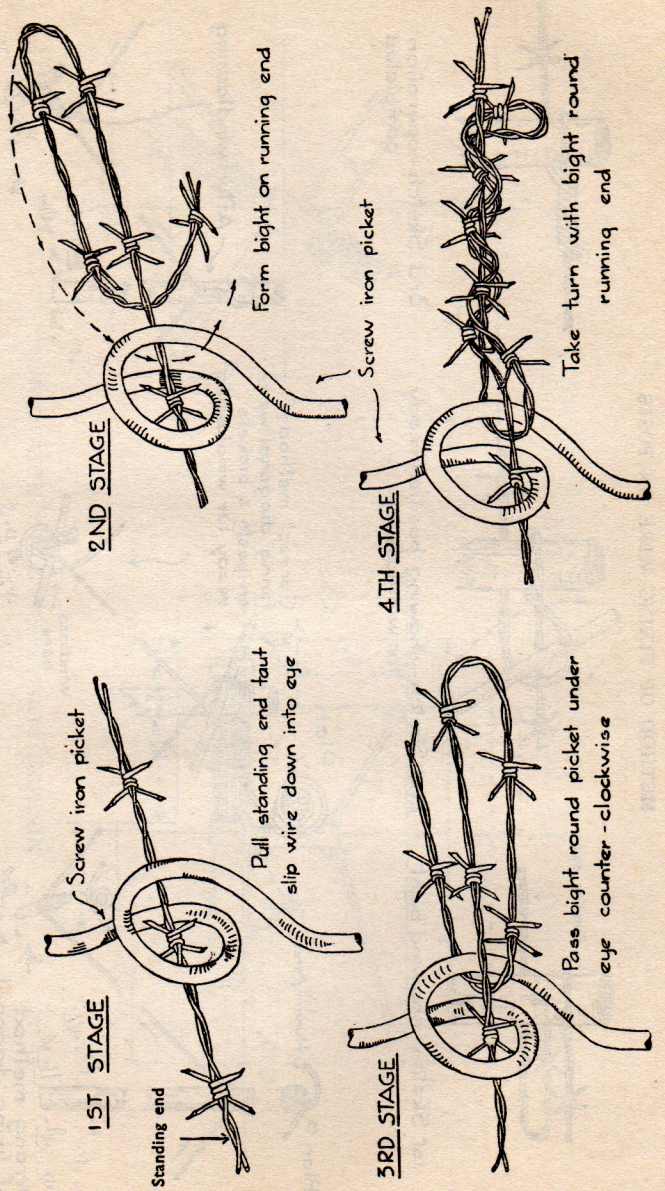
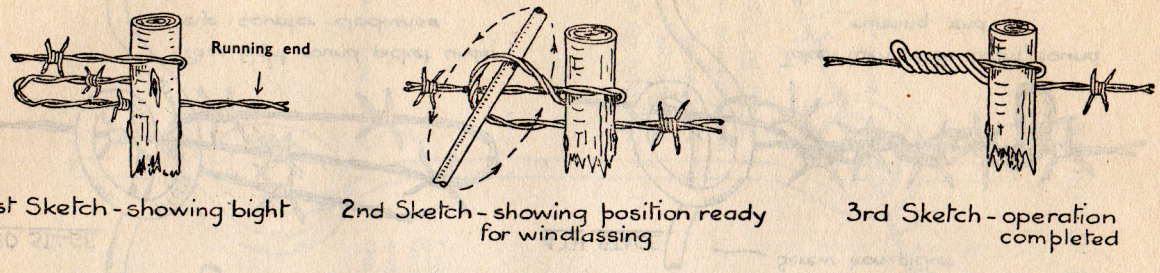


PLATE 16.

METHOD OF FIXING WIRE ON POSTS

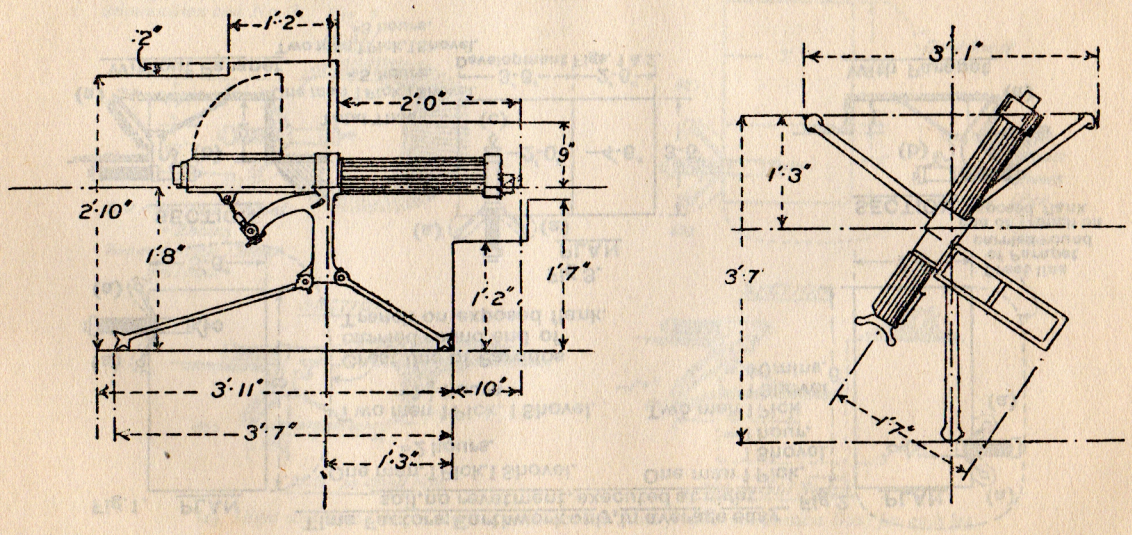


[See Sec. 26, 7.

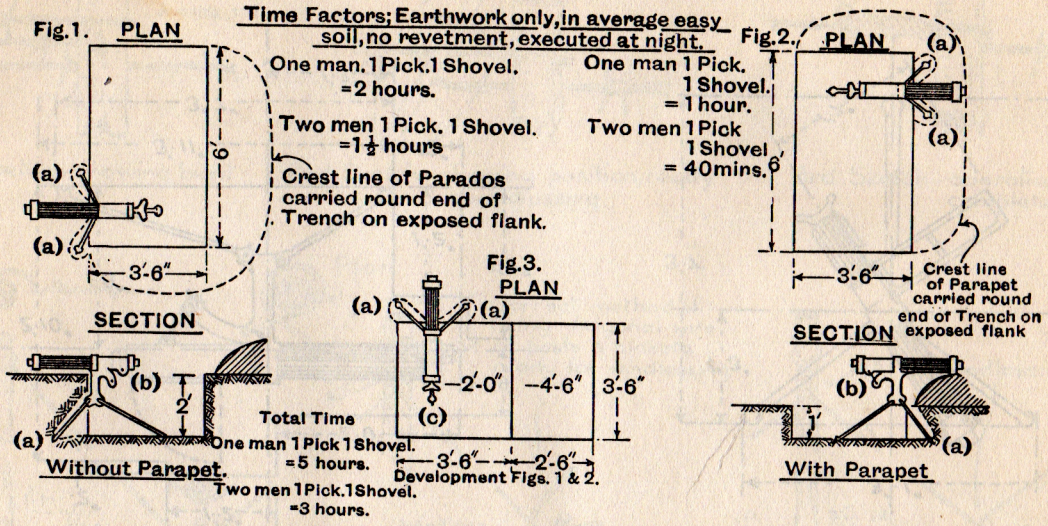
See Sec. 36, 1.]

PLATE 17.

MINIMUM DIMENSIONS OF M.G. EMPLACEMENT



HASTY M.G. EMPLACEMENTS



(a) *Slight undercut (can be revetted with wooden Slats from Ammunition Box) for each leg*
(b) *Gun mounted in highest position*
(c) *2' is Maximum depth to enable No. 1 to fire in sitting position*
Fig. 3 shows normal development of Figs. 1 and 2 when time permits

[See Sec. 36, 2.

See Sec. 36, 2.]

HASTY M.G. EMPLACEMENTS

The reason for more room on the right of M.G. is to allow for ammunition and No. 2.

Fig. 1
PLAN
1'9"
1'2"
(a)
(a)
One man 1 Pick 1 Shovel = 2 hours
Two men 1 Pick. 1 Shovel = 1 hour

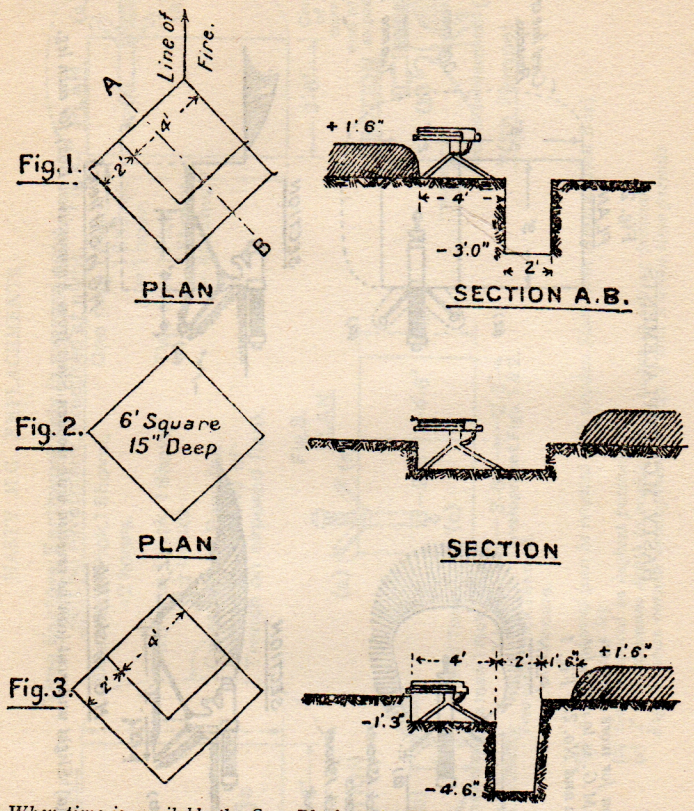
Fig. 2
PLAN
3'
3'3"
2'4"
(a)
(a)
Crest line of Parados
One man 1 Pick 1 Shovel = 2 hours
Two men 1 Pick 1 Shovel = 1 hour

SECTION
(a)
1'7"
4'
3'
M.G. in Shell Hole

SECTION
1'7"
(a)
4'
3'
3'
M.G. in Slit Trench

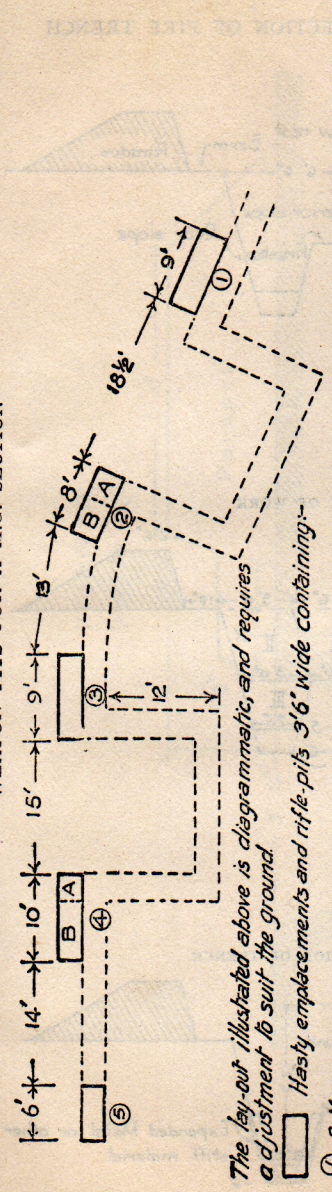
(a) *Slight undercut (can be revetted with wooden Slats from Ammunition Box) for each leg.*

TYPES OF M.G. EMPLACEMENTS IN OPEN GROUND



When time is available the Gun Platform in Fig. 3 should be revetted. The Emplacements may also be connected by cutting a trench rearwards from the rear angle of the Emplacement, these trenches joining a lateral communication trench and giving access to the control post, etc.

WEAPON PITS FOR A M.G. SECTION



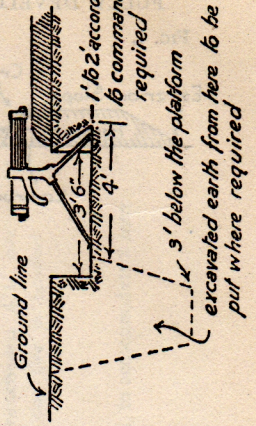
The lay-out illustrated above is diagrammatic, and requires adjustment to suit the ground.

Hasty emplacements and rifle-pits 3'6" wide containing:-

① 3 Men
② 1 gun and 2 nos.
③ Sec. Comdr. range-taker, and orderly
④ 1 gun and 3 nos
⑤ Sec. Cpl. and 1 man.

The dotted lines show a method of joining up the pits for inter-communication. The portion of the original pit marked A is subsequently dug away to allow No 2 to stand in it. When not in use this short length of trench should be concealed from the air (See Sec. 4-5, 4.) The portion marked B remains as the platform, after the trench behind it is dug to allow No 1 to stand

SECTION THROUGH M.G. PIT AT B
Showing in dotted lines the trench dug behind the platform in which No 1 stands.



FULLY DEVELOPED SECTION OF FIRE TRENCH

FIG. 1.

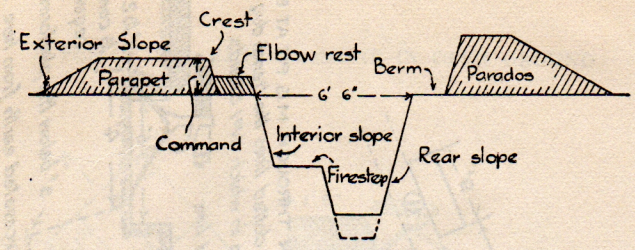


FIG. 2. ORDER OF WORK

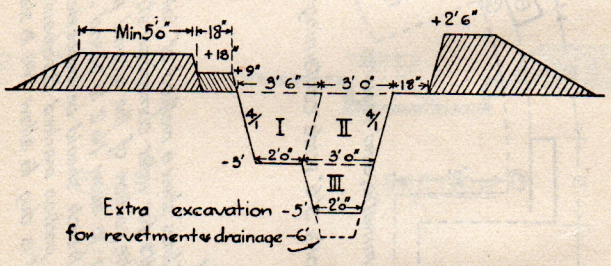
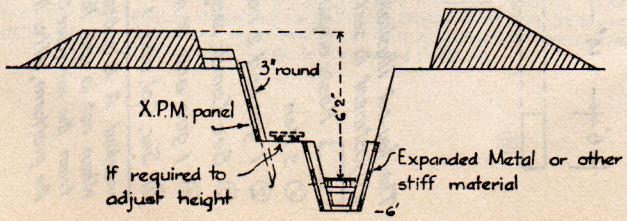
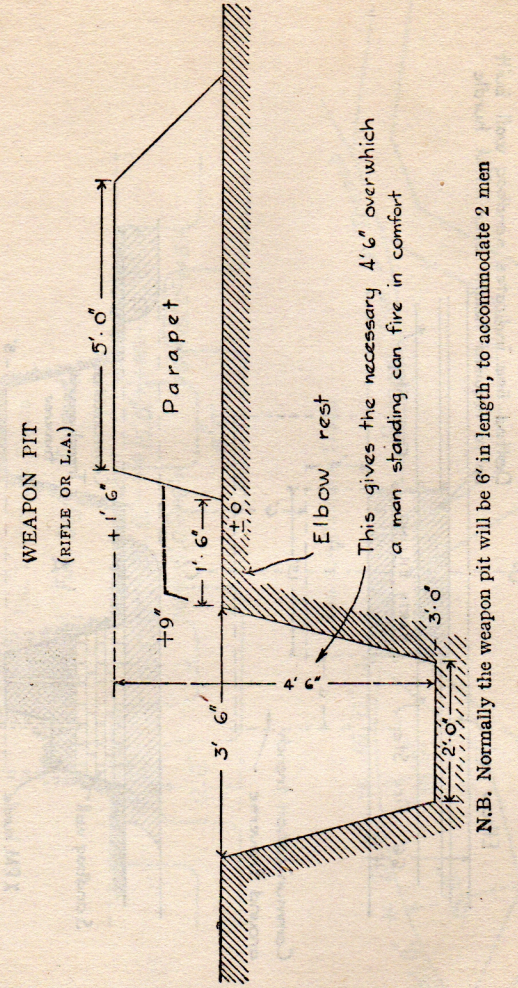


FIG. 3. FINAL SECTION OF TRENCH

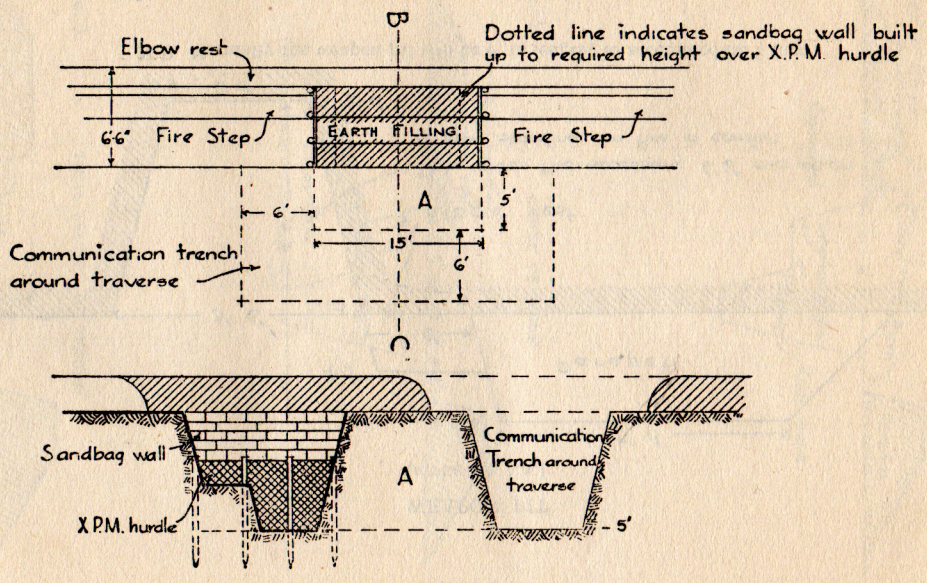




N.B. Normally the weapon pit will be 6' in length, to accommodate 2 men

PLATE 24.

SHOWING TRAVERSE MADE IN UNTRAVERSED TRENCH



SECTION B.C.

[See Sec. 37, 8, iii.

[See Sec. 37, 8, v.]

PLATE 25.

TRACE OF TRENCHES

FIG. 1.—SQUARE TRACE

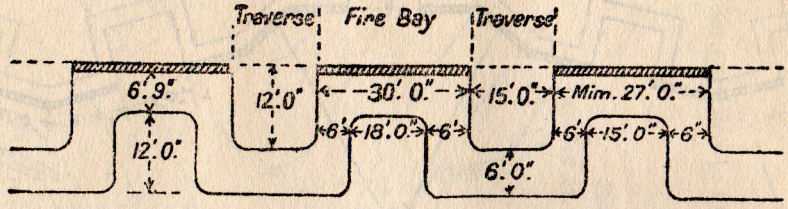
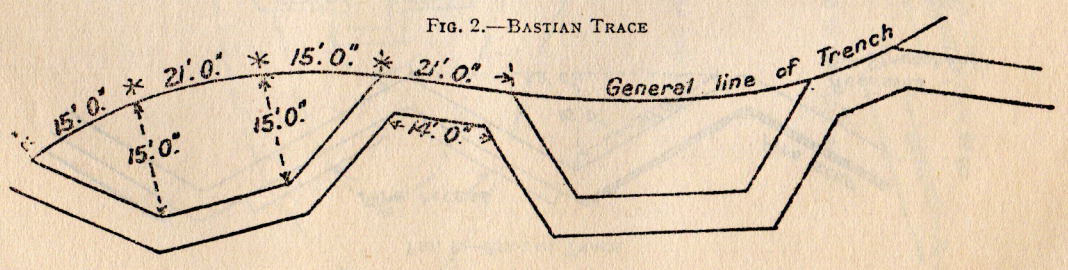


FIG. 2.—BASTIAN TRACE



TRACE OF TRENCHES

FIG. 1.—ZIG-ZAG TRACE

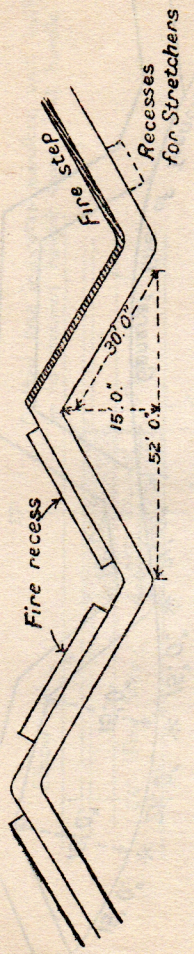
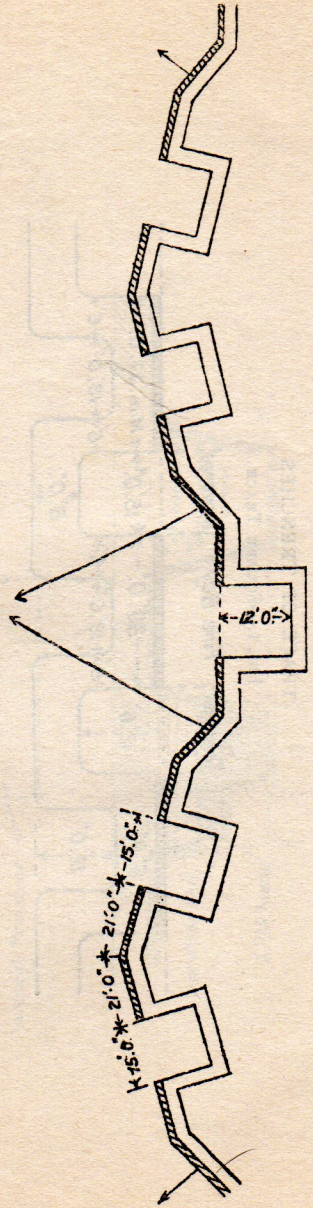


FIG. 2.

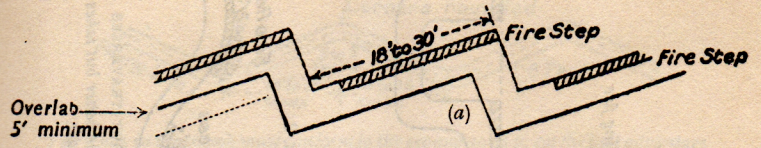


Showing application of various forms of trace to the ground.

ALTERNATIVE TRACE OF TRENCHES

FIG. 1.

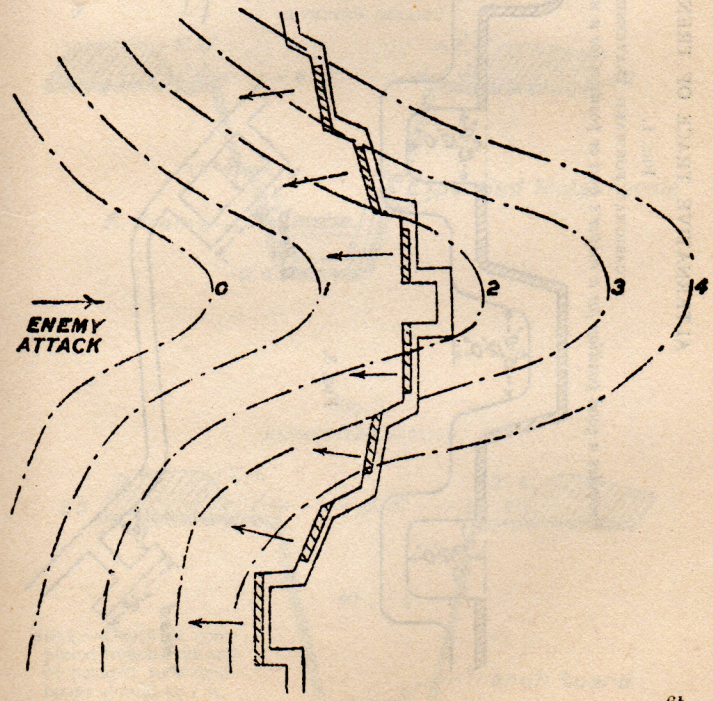
DOG LEGS



(*a*) Angle may be from 90 to 120 degrees

FIG. 2.

EXAMPLE OF USE OF DOG LEGS



ALTERNATIVE TRACE OF TRENCHES

FIG. 1.

OCCASIONAL FORWARD TRAVERSE

Provides a good position for a sniper's post or position for a machine gun for flanking fire

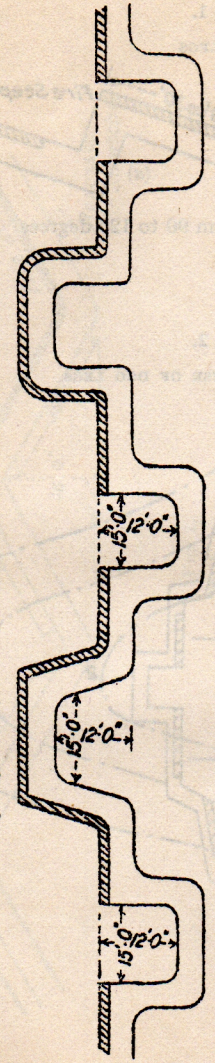


FIG. 2.

CURVED WITHOUT TRAVERSES

A traversed trench is the better but takes longer to dig

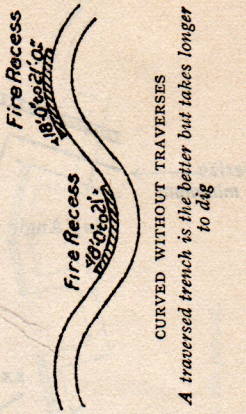
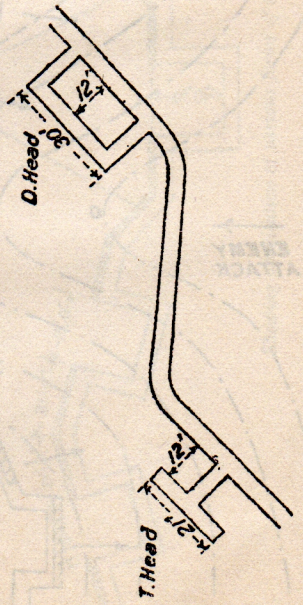


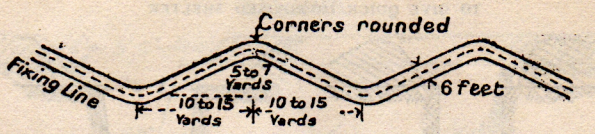
FIG. 3.



TRACE AND SECTION OF COMMUNICATION TRENCH

FIG. 1.

TRACE



The bends in the trench must conform to the ground so as to get the best advantage in cover, but roughly the distance between bends should not be more than 15 yards up to reserve trenches and not more than 10 yards between reserve and fire trenches.

FIG. 2.

REVETTED SECTION

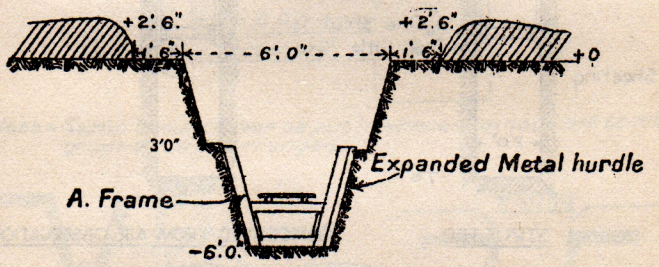
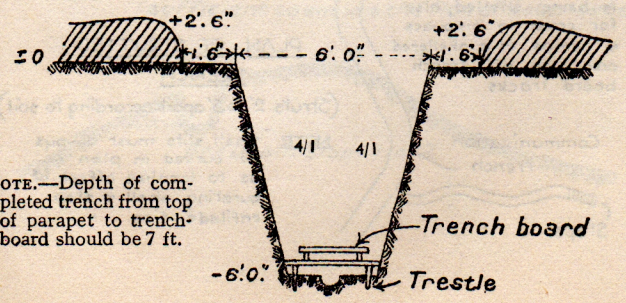


FIG. 3.

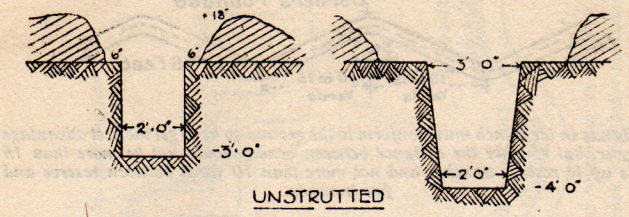
UNREVETTED SECTION



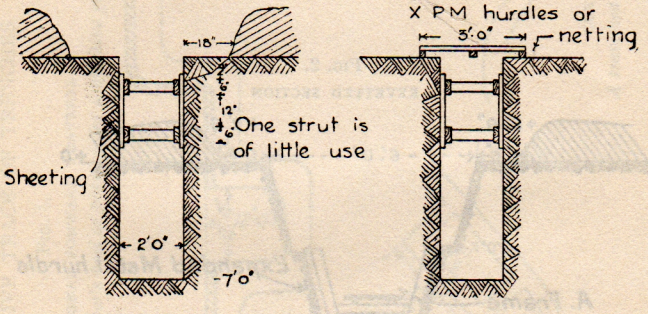
NOTE.—Depth of completed trench from top of parapet to trench-board should be 7 ft.

SHELL SLITS

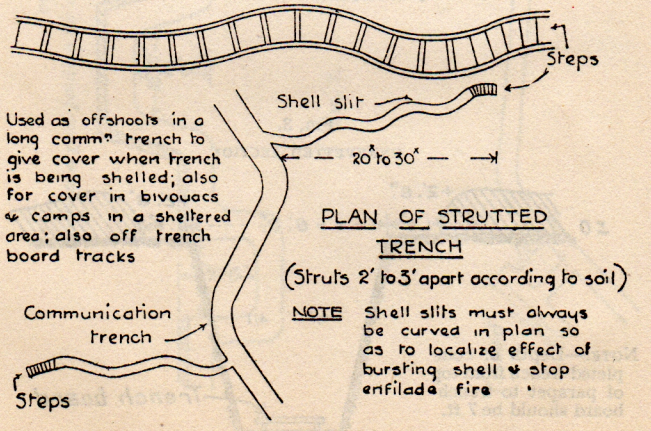
TO GIVE QUICK IMPROVISED SHELTER



UNSTRUTTED



STRUTTED CONCEALED FROM AIR OBSERVATION



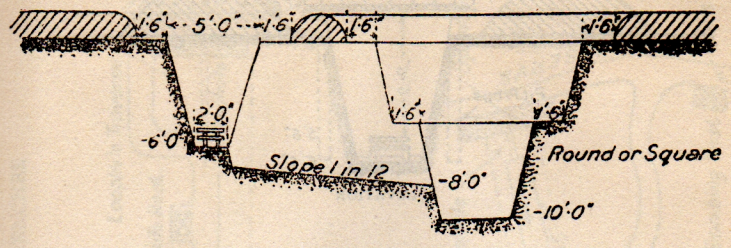
PLAN OF STRUTTED TRENCH

(Struts 2' to 3' apart according to soil)

NOTE Shell slits must always be curved in plan so as to localize effect of bursting shell & stop enfilade fire.

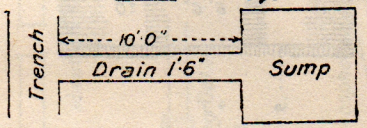
TYPE OF SUMP

SECTION.



PLAN

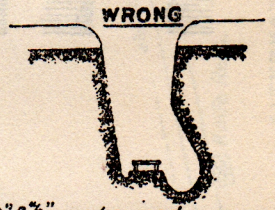
Sump consists of a circular or square hole revetted if necessary)

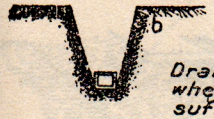


Note:- Sump should never be put in where drainage out to lower ground can be arranged.

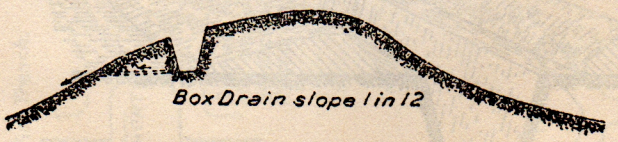
Drain formed of corrugated iron sheets (a). Or boxed (lined with wooden box (b).

WRONG





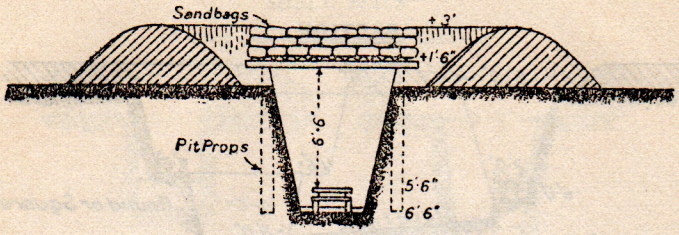
Drains of the Types "a" & "b" can be used when a trench is sited on sloping ground sufficient to ensure the flow of water as below.



Box Drain slope 1 in 12

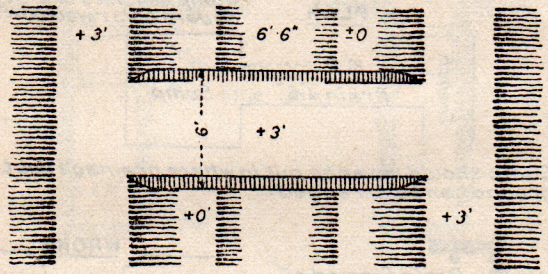
BRIDGE TRAVERSE

FIG. 1.



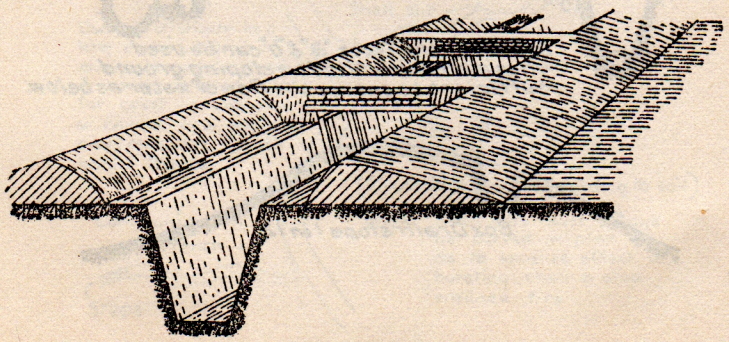
ELEVATION

FIG. 2.



PLAN

FIG. 3.



PERSPECTIVE SKETCH

METHODS OF DEFENCE OF COMMUNICATION TRENCHES

FIG. 1.

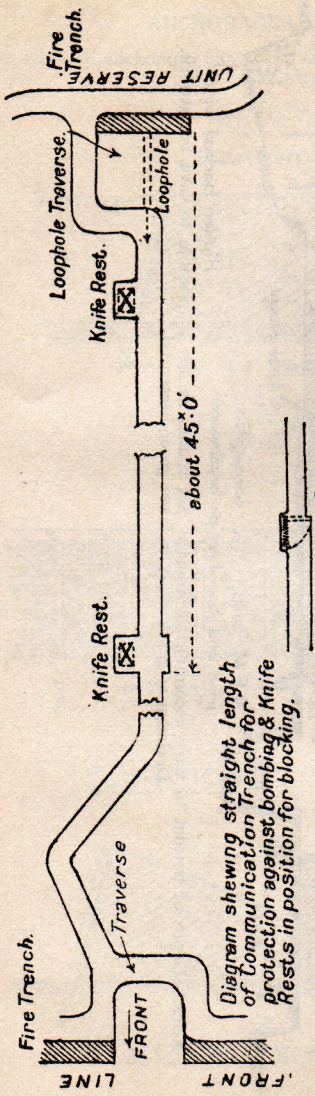
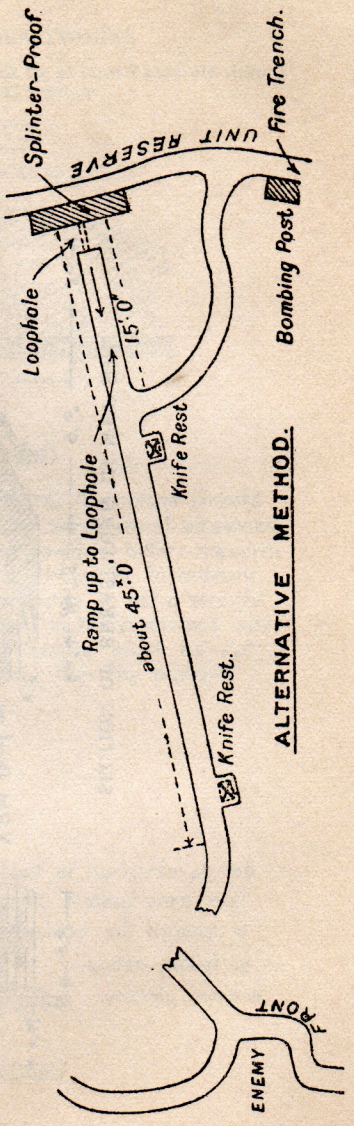
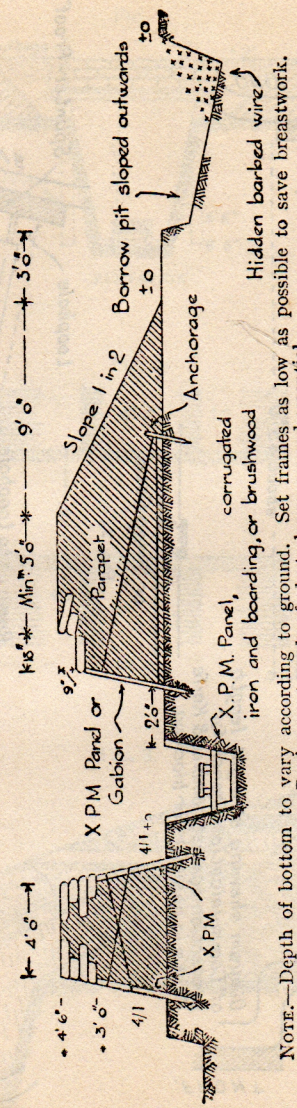


FIG. 2.



or Swing Gate.

SECTION OF BREASTWORK IN WET SOIL



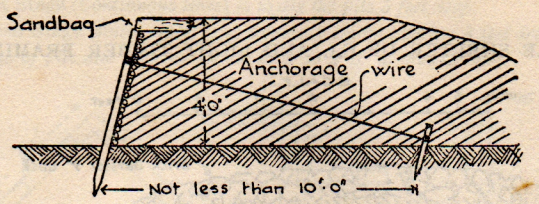
NOTE.—Depth of bottom to vary according to ground. Set frames as low as possible to save breastwork. Drainage at grade of 1 in 10 to lower ground essential.

ANCHORAGES IN BREASTWORKS

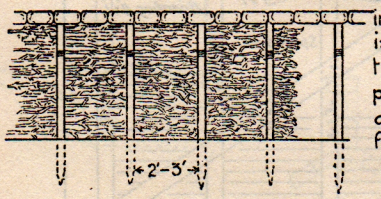
NOTE.—All anchorages should be held back by at least 8 separate strands of binding wire twisted together

REVETMENTS

BRUSHWOOD PACKING

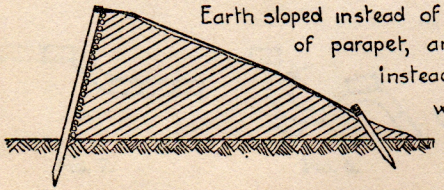


SECTION
(RIGHT METHOD)



NOTE: Anchorage pickets and wires must be placed in position before the earth is thrown up. In ordinary trenches to get a straight pull in the anchorage wire a groove must be cut for it in the parapet.

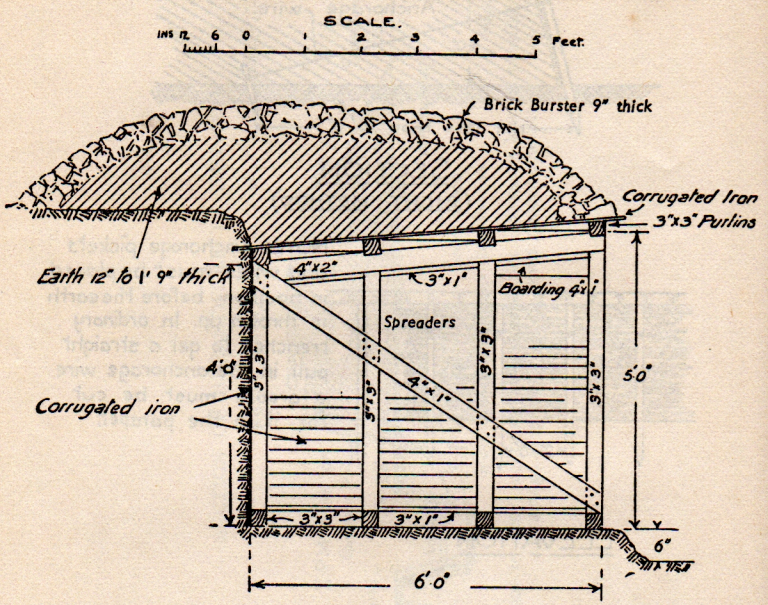
ELEVATION



Earth sloped instead of horizontal at top of parapet, anchor wire over instead of through & wooden picket is wrongly inclined

SECTION (WRONG METHOD)

SIMPLE SHELTER OF C.I. AND LIGHT TIMBER FRAMING



TYPES OF SECTION POSTS

Showing how Weapon-Pits may be connected up for inter-communication. The drawings are diagrammatic only, and must be adapted in every case to suit the ground. Each pit should be dug at right angles to the required direction of fire. The pits shown are for 2 men each, but they may be dug for one or more men as required. A suitable length is 3 feet per man.

First Stage (*Continuous lines*) *is to dig the pits 3 feet deep.*

Second Stage (*dotted lines*) *is to connect them by trenches 3 feet deep.*

Width of pits and trenches should be 3' to 3' 6" at ground level.

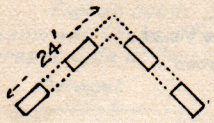


FIG. 1.

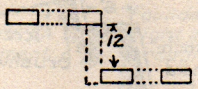


FIG. 2.

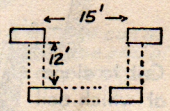


FIG. 3.

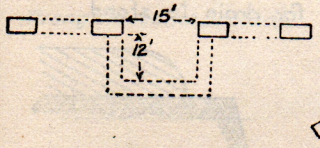


FIG. 4.

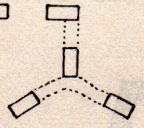


FIG. 5.

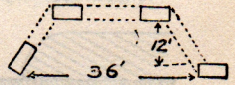


FIG. 6.

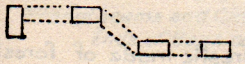


FIG. 7.

FIG. 8.

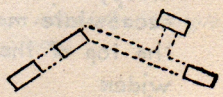


FIG. 9.

METHOD OF REVETMENT WITHOUT REVETTING FRAME

FIG. 1.

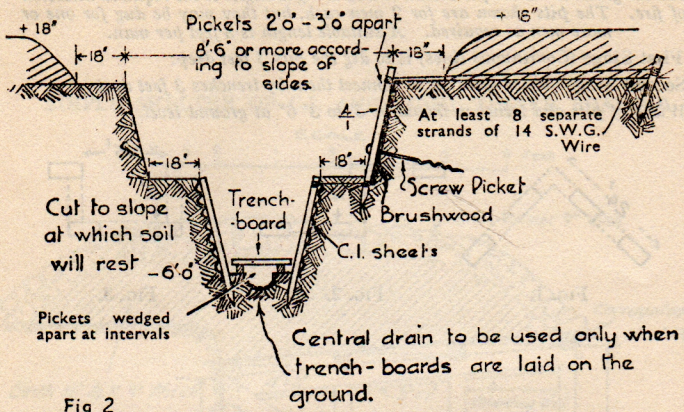
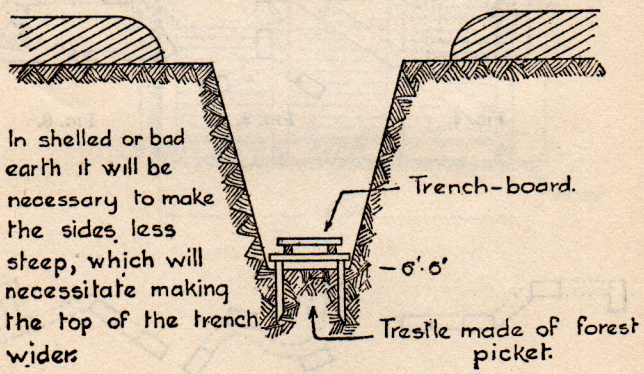
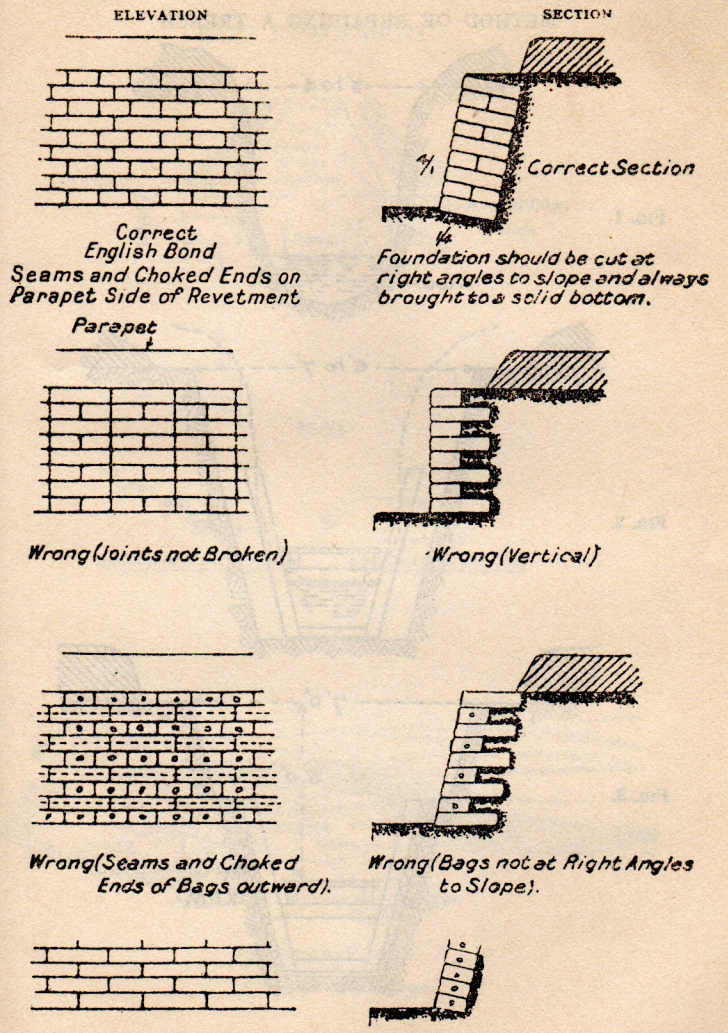


Fig 2

Trench-board laid on trestles 3' 0" apart where soil is too soft for drain to stand.



SANDBAG REVETMENT



METHOD OF REPAIRING A TRENCH

FIG. 1.

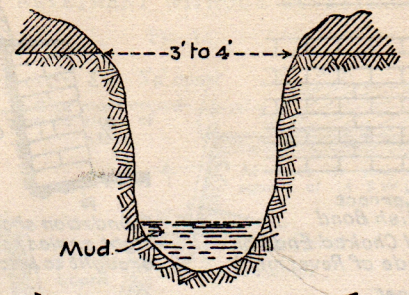


FIG. 2.

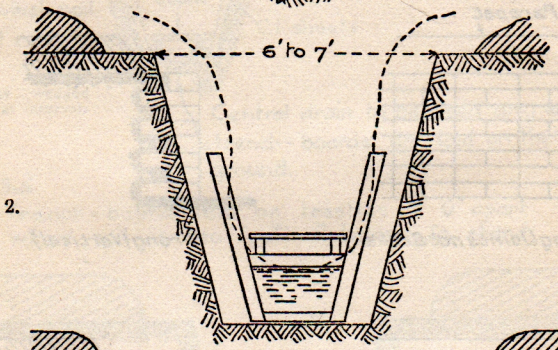
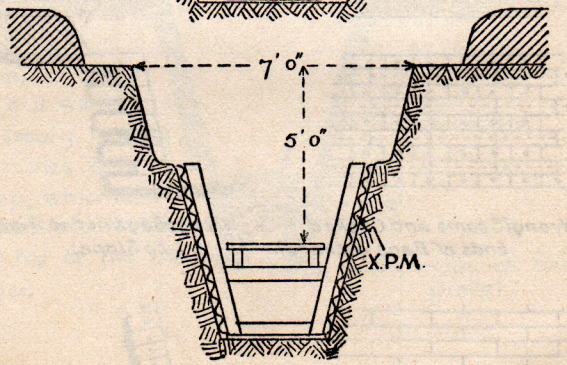
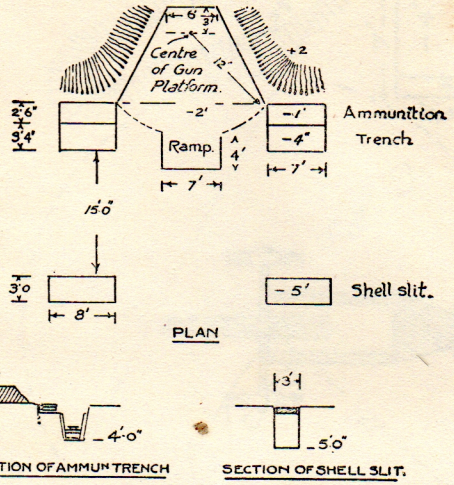
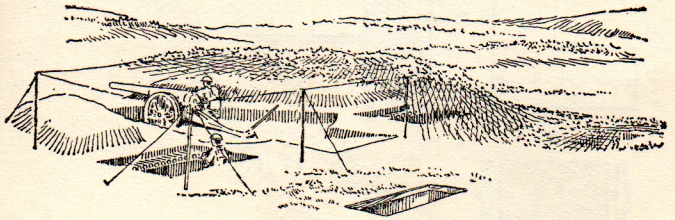


FIG. 3.



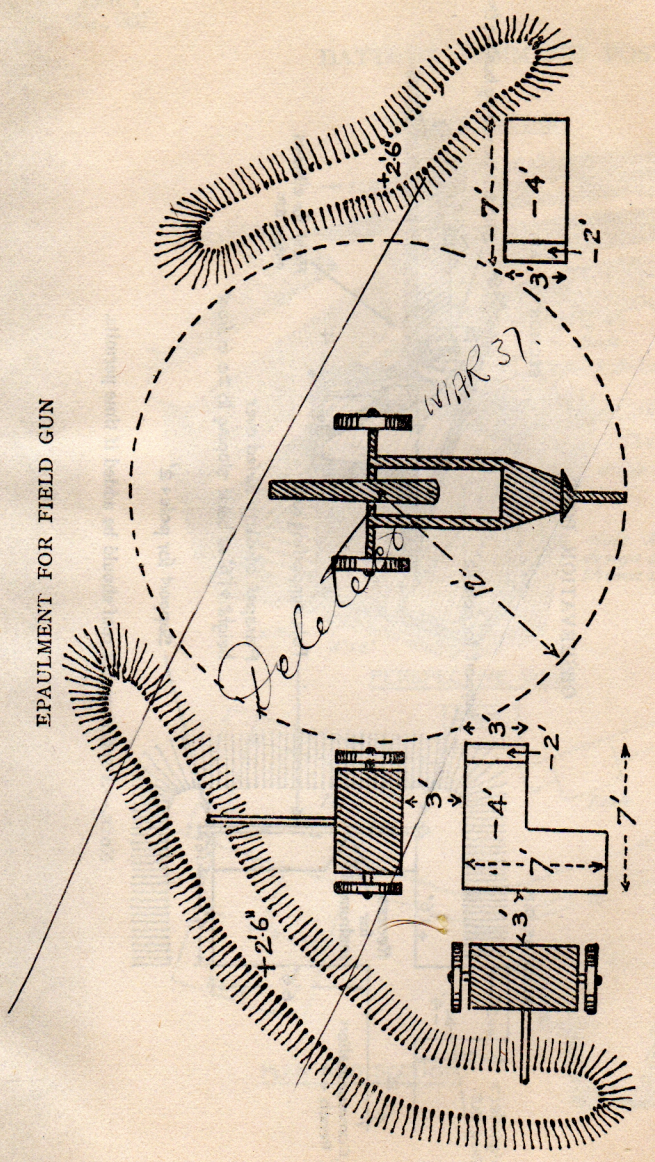
GUN EPAULMENT.





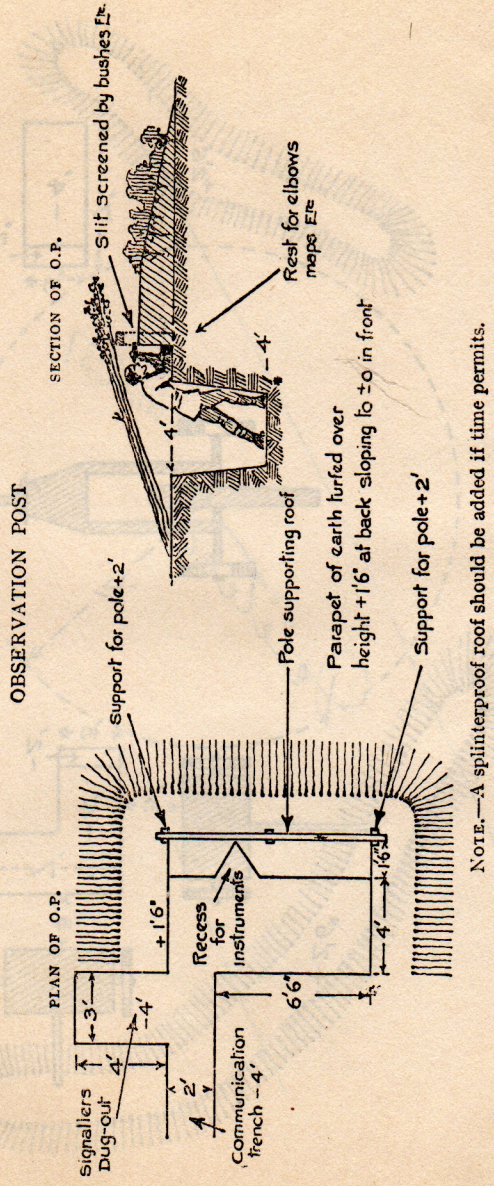
PERSPECTIVE VIEW.

Showing Camouflage.



EPAULMENT FOR FIELD GUN

OBSERVATION POST

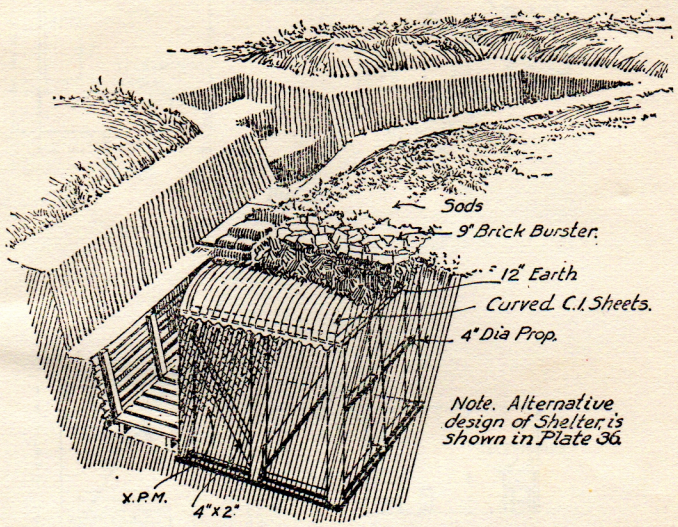


NOTE.—A splinterproof roof should be added if time permits.

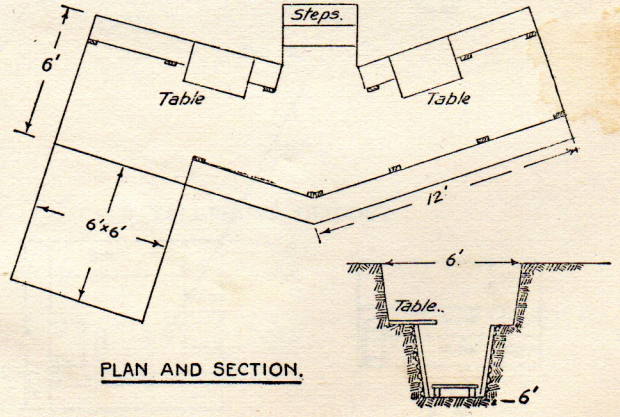
Amdt. 2
Mar., 1937

BATTERY COMMAND POST.

TYPICAL DESIGN



PERSPECTIVE VIEW.



PLAN AND SECTION.

BATTERY COMMAND POST

SHOWING INTERIOR ARRANGEMENTS

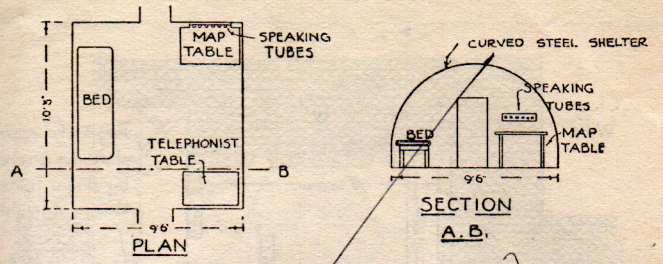


FIG. 1.

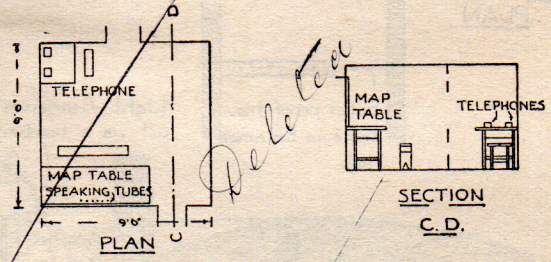


FIG. 2.

TELEPHONE DUG-OUT

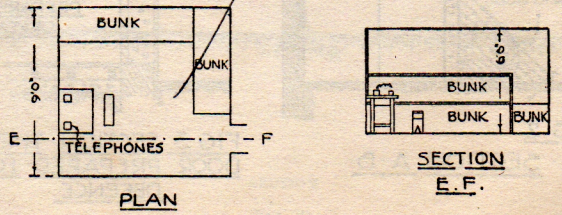


FIG. 3.

DEFENCE OF A HOUSE

NOT EXPOSED TO ARTILLERY FIRE

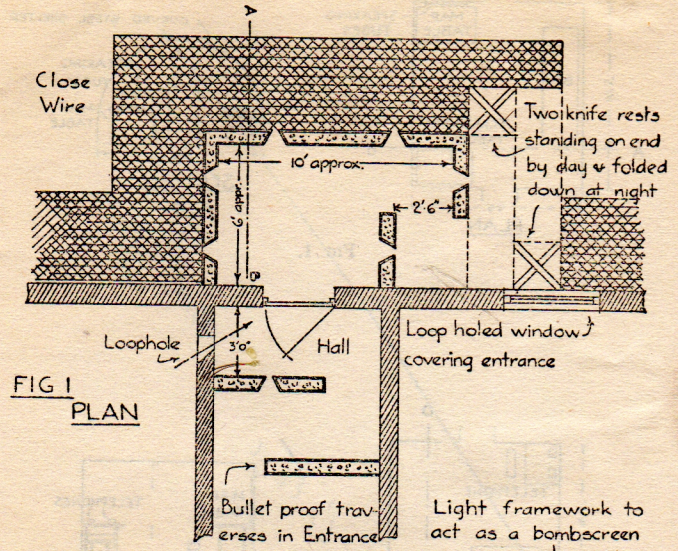


FIG 1 PLAN

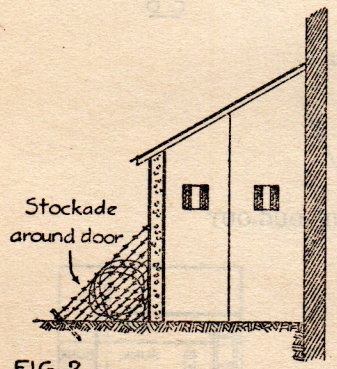


FIG 2 SECTION A-B

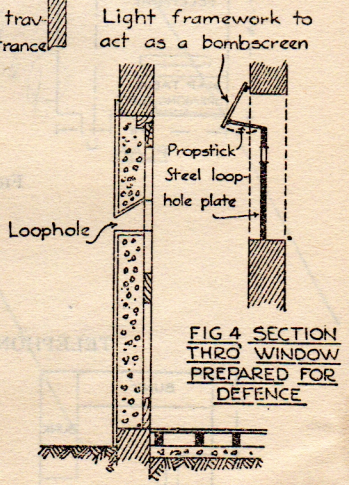
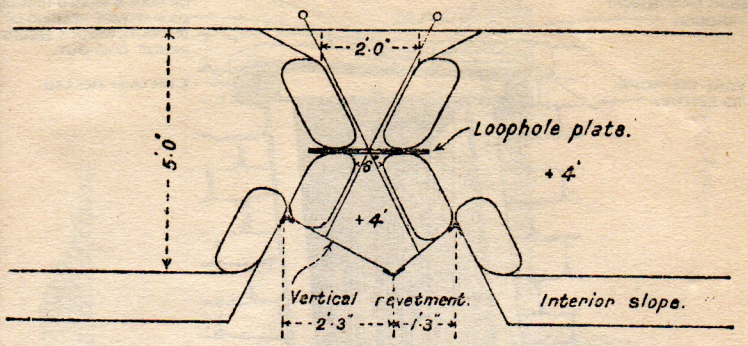


FIG 4 SECTION THRO WINDOW PREPARED FOR DEFENCE

FIG 3 SECTION THRO DOOR PREPARED FOR DEFENCE

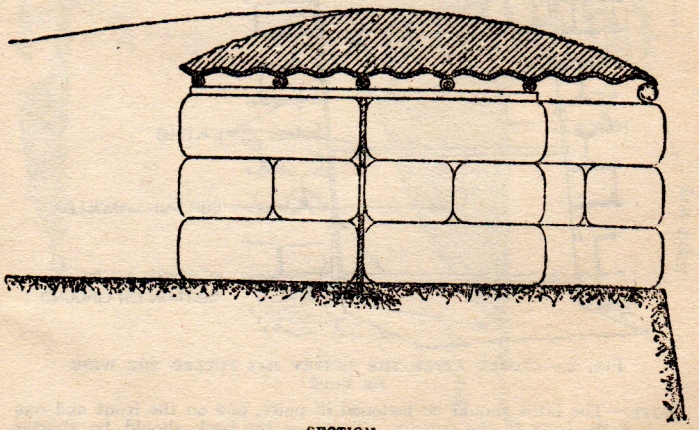
LOOPHOLES

EXTERIOR SLOPE



PLAN AT LEVEL 4 FEET SHOWING FIRST LAYER OF SANDBAGS FORMING LOOPHOLE

FIG. 1.



SECTION

FIG. 2.

GAS-PROOF CURTAIN

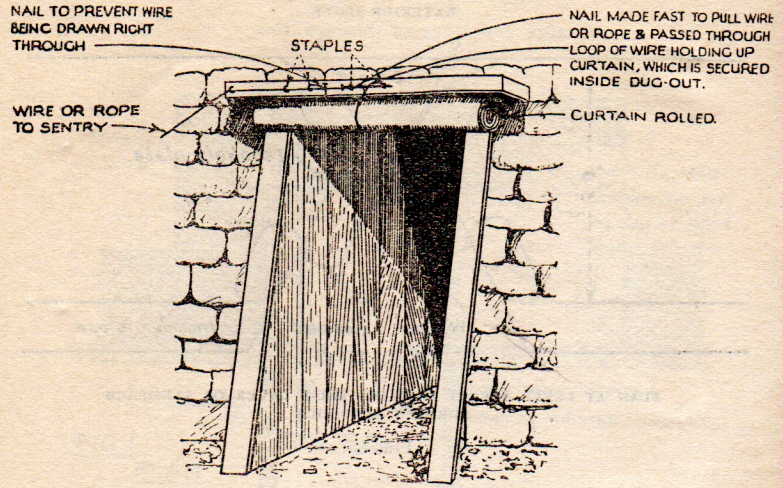


FIG. 1.—OPEN

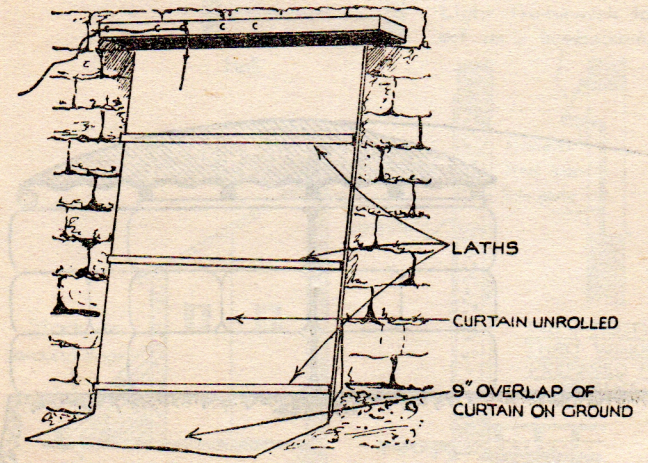


FIG. 2.—CLOSED AFTER THE SENTRY HAS PULLED THE WIRE OR ROPE

NOTE.—The laths should be fastened in pairs, one on the front and one on the back of the curtain. Those on the back should be shorter than those on the front to allow for the curtain lying close against the wooden frame.

PROTECTIVE WORKS IN LOOSE SAND

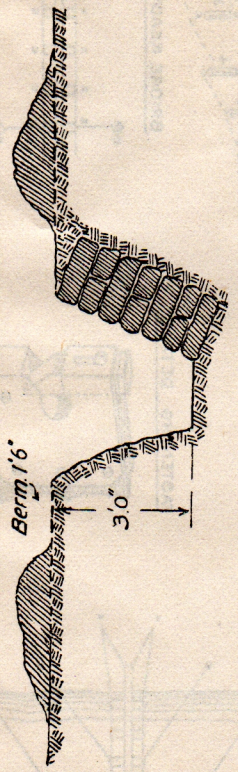


FIG. 1.—FIRST STAGE

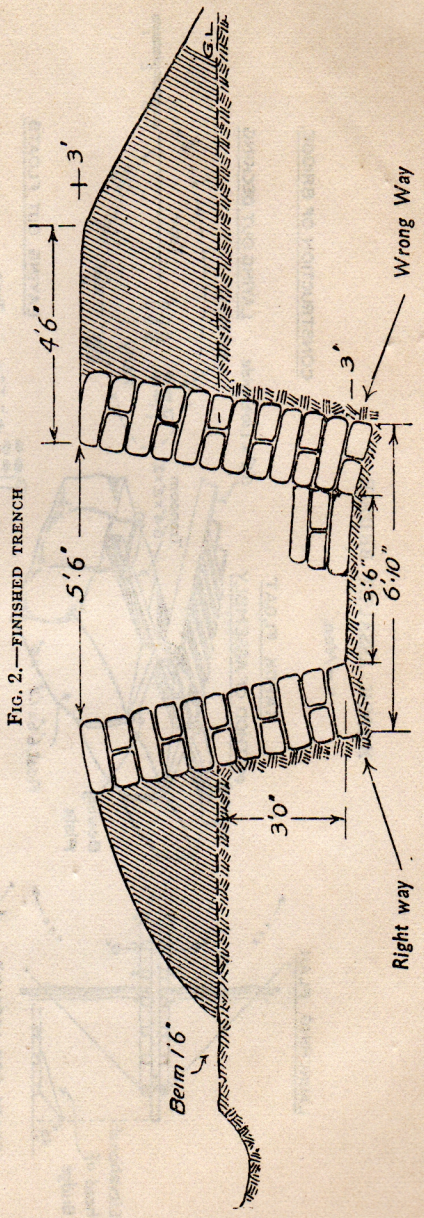
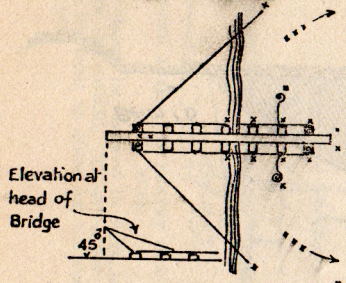


FIG. 2.—FINISHED TRENCH

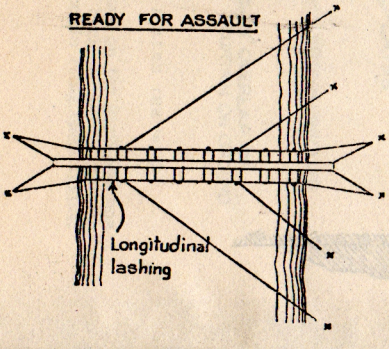
KAPOK ASSAULT BRIDGE

x = Men.

LAUNCHING PLAN

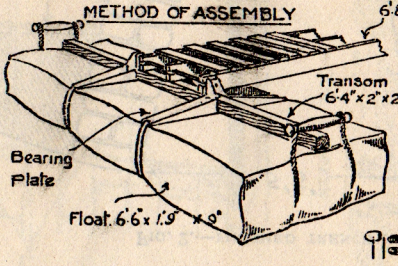


READY FOR ASSAULT

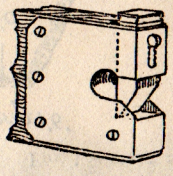


KAPOK FLOAT

METHOD OF ASSEMBLY

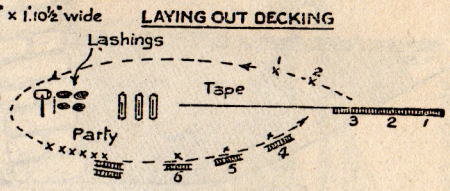


FASTENING DETAIL

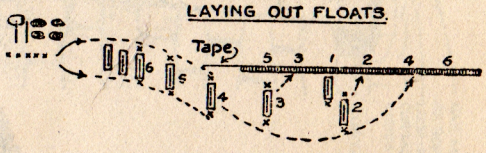


CONSTRUCTION OF BRIDGE.

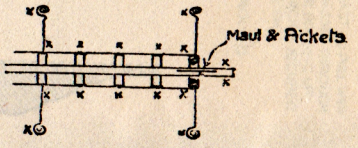
LAYING OUT DECKING



LAYING OUT FLOATS.



BRIDGE READY FOR CARRYING.



[See Sec. 62.

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